Final
Environmental Baseline Survey Report For The Plum Brook Reactor Facility Decommissioning Project

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TABLE OF CONTENTS

APPENDICES:

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

ACM	Asbestos Containing Material
ASTM	American Society for Testing and Materials
BG	Block Group
CFR	Code of Federal Regulations
CIB	Community Information Bank
CRP	Community Relations Plan
Ea.	Each
EA	Environmental Assessment
EBS	Environmental Baseline Survey
EBSR	Environmental Baseline Survey Report
FUDS	Formerly Used Defense Site
GRC	Glenn Research Center
H-3	Tritium
LBP	Lead-Based Paint
LF	Linear Feet
MPCs	Maximum Permissible Concentrations
NASA	National Aeronautics and Space Administration
NRC	Nuclear Regulatory Commission
OPDES	Ohio Pollutant Discharge Elimination System
PBOW	Plum Brook Ordnance Works
PBRF	Plum Brook Reactor Facility
ppm	parts per million
RBC	Risk-Based Concentration
PCBs	Polychlorinated Biphenyl's
SF	Square Feet
RCRA	Resource Conservation and Recovery Act
SVOCs	Semivolatile Organic Compounds
TSCA	Toxic Substances Control Act
TLD	Thermoluminescent Detector
USAEC	United States Army Corps of Engineers
UST	Underground Storage Tank
VOCs	Volatile Organic Compounds

EXECUTIVE SUMMARY

The National Aeronautics and Space Administration (NASA), Glenn Research Center (GRC), has no further need for the Plum Brook Reactor Facility (PBRF) in support of its mission. The NASA PBRF is located at the Plum Brook Station in Sandusky, Ohio, and was defueled and shut down in 1973. At that time, the U. S. Nuclear Regulatory Commission (NRC) license for the facility was changed to "possess but do not operate" status. NASA proposes to terminate the license, which is still in effect for the facility.

This Environmental Baseline Survey Report (EBSR) was prepared to support the PBRF Decommissioning Project by identifying and inventorying all known environmental conditions at and near the PBRF that affect, or could be affected by, the Decommissioning Project. As such, this document contains an overview of the environmental setting at the PBRF and includes a comprehensive audit of the PBRF and adjacent areas within a one-half mile radius of the facility. This survey was performed in accordance with the American Society for Testing and Materials Standard D6008-96, *Standard Practice for Conducting Environmental Baseline Surveys*.

As part of this survey, documents concerning the environmental condition of the property were reviewed, personnel who work/worked at the facility were interviewed, and a visual inspection of the property was conducted. Any data gaps present that would prevent a complete property characterization were identified. A brief summary of the results of the EBS is presented below.

Due to the nature of the facility, environmental monitoring conducted while the facility was active focused solely on radiological aspects. Comprehensive radiological characterization efforts conducted in 1985 and in 1998 appear to have adequately characterized the radiological status of the buildings and structures at the PBRF.

Since the facility has been shut down, sampling for environmental contaminants other than radionuclides has occurred. This sampling has been conducted in three separate investigations: underground storage tanks located adjacent to the Services Equipment Building; a former explosive manufacturing facility that was present in what is now the southwestern part of the PBRF; and recent environmental characterization efforts in various areas associated with the decommissioning project. Sampling and analyses conducted at the former two areas appears to have adequately characterized the nature and extent of the related environmental contamination, while the most recent soil sampling effort identified several areas of low-level contamination. The concentrations detected were well below available Risk Based Concentration (RBC) screening guidance levels, except for one sample that contained an estimated concentration of a semi-volatile organic compound above the RBC.

Various data gaps were identified during preparation of this EBSR. Most of these data gaps are due to a lack of data on certain types of potential contaminants (based on site activities and history), while others are lack of sampling in certain areas. One was identified during the review of historic aerial photographs. A plan has been developed to fill these data gaps that includes sampling the areas of concern for the appropriate parameters. By collecting these additional data, a complete characterization of the environmental condition of the property will be accomplished. In addition, installing monitoring wells near the southern boundary of the PBRF will address potential contaminant migration from adjacent areas onto the PBRF.

1.0 PURPOSE OF THE ENVIRONMENTAL BASELINE SURVEY

The National Aeronautics and Space Administration (NASA), Glenn Research Center (GRC), has no further need to use the Plum Brook Reactor Facility (PBRF) in support of its mission. The NASA PBRF is located at the Plum Brook Station in Sandusky, Ohio, and was shut down in 1973. At that time, the U. S. Nuclear Regulatory Commission (NRC) license for the facility was changed to "possess but do not operate" status. This license is still in effect for the facility. NASA proposes to terminate the license according to the NRC's regulations radiological criteria for license termination (10 Code of Federal Regulations [CFR] Part 20, Subpart E).

This Environmental Baseline Survey Report (EBSR) was prepared to support the PBRF Decommissioning Project by identifying and inventorying all known environmental conditions at and near the PBRF that affect, or could be effected by, the Decommissioning Project. As such, this document contains an overview of the environmental setting at the PBRF and includes a comprehensive audit of the PBRF and its surrounding environs.

The proposed action of the Decommissioning Project is to decontaminate the PBRF to levels consistent with NRC's unrestricted release criteria, to take measurements to verify that decontamination is complete, to request that NRC terminate the license without restrictions, and then to demolish the buildings and regrade the area. NASA will retain the land as buffer area within the Plum Brook Station. As part of this action, NASA is preparing other documents concerning the environmental aspects of the Decommissioning Project, including an environmental assessment (EA) as required by the *National Environmental Policy Act*.

1.1 BOUNDARIES OF THE PROPERTY AND SCOPE OF SURVEY

The PBRF is located in the northern portion of the 2,950 ha (6,400 acre) Plum Brook Station, located about 6 km (4 miles) south of Sandusky, Ohio (Figure 1.1-1). The PBRF includes 21 buildings/structures located on approximately 11 ha (27 acres) of nearly level land. The topography in the area slopes gently northward toward Lake Erie. The average slope of the land is less than 6%. Elevation ranges from about 191 to 207 m (625 to 680 ft) above sea level. The elevation at the PBRF is about 191 m (625 ft) above sea level (Ref. #53). The site layout is shown on Figure 1.1-2.

Two buildings and a water storage tower located in the northwest area of the PBRF (not shown on Figure 1.1-2) are outside the scope of this document because they were removed from the NRC license in accordance with NRC regulations in 1979.

Adjacent properties within the scope of this Environmental Baseline Survey (EBS) are those within an approximately one-half mile radius of the PBRF boundary. These areas include a wooded area to the north within the Plum Brook Station boundary, residential areas adjacent to the northern boundary of the Station, and a mixture of open fields and wooded areas to the east, west, and south. With the exception of the residential area to the north, all other adjacent areas are within the boundaries of Plum Brook Station. Aerial photos of the PBRF and surrounding areas are provided in Appendix B.

2.0 SURVEY METHODOLOGY

2.1 APPROACH AND RATIONALE

This EBS was performed in accordance with the American Society for Testing and Materials (ASTM) Standard D6008-96, *Standard Practice for Conducting Environmental Baseline Surveys*. The approach outlined in this standard practice involves several activities:

- A site visit that includes a visual inspection of the condition of the parcel and adjacent areas;
- Detailed search and review of records produced by the facility, including an inventory of hazardous substances used or stored at the facility;
- Review of Federal and state databases on releases of hazardous substances and various other environmental data concerning the parcel and adjacent areas;
- Review of property tax files or similar resources documenting the past uses of the parcel ;
- Review of historic aerial photographs to aid in documenting past uses of the parcel;
- Interviews with persons knowledgeable about the activities carried out at the facility;
- Identification of ongoing response actions that have been taken at or adjacent to the parcel; and
- Identification of sources of contamination at the parcel, or at adjacent areas which could migrate to the parcel in question.

The overall goal of the EBS is to determine the environmental condition of the property in question - in this case, the approximately 11 ha (27 acres) and 21 buildings/structures that comprise the PBRF. In this process any data gaps present that would prevent a complete property characterization are identified.

The primary effort involved in creating this Environmental Baseline Survey Report (EBSR) was collecting and reviewing the various records collected as part of the survey. Records were searched and reviewed during the site visit to the PBRF and also during a visit to the U.S. Army Corps of Engineers offices in Huntington, West Virginia to review the Administrative Record for the Formerly Used Defense Site (FUDS) activities at the PBS. As discussed in Section 3.1 of this document, the U.S. Army originally annexed the land now comprising the Plum Brook Station in 1940 in order to establish the Plum Brook Ordnance Works (PBOW). The PBOW operated from 1941 to 1945.

Interviews were also conducted with some PBRF personnel. Physical walk-through site inspections were accomplished for all accessible facilities at the PBRF. Certain areas at the facility are not accessible to personnel without specialized safety training due to radiological contamination. The project team visited not every space used as typical offices. Facilities inspected and personnel interviewed/contacted are summarized below in Section 2.1.2.

A title search is also normally conducted as part of an EBS. For this EBSR, however, a title search was not performed due to the well-documented history of the property (see Section 3.1).

2.1.1 List and Description of Documents Reviewed

Table 2.1.1-1 provides a listing of the documents reviewed during this EBS. These references are numbered in the table and are referred to by number elsewhere in this document. In addition, NASA GRC maintains a Community Information Bank (CIB) containing relevant information on the Decommissioning Project in the Firelands College Library in Huron, Ohio. The documents included in the CIB are varied, and include technical reports, historical information, and project management plans.

Table 2.1.1-1. ***List of Documents Reviewed for the EBS***

Ref. No.	Document
1	Information for Experiment Sponsors for NASA Plum Brook Reactor Facility, NASA Glenn Research Center, October 1968
2	NASA Technical Memorandum, Beryllium Behavior in the NASA Plum Brook Reactor, Document # NASA TM X-67894, NASA Lewis Research Center, August 1971
3	An Evaluation of the Options for Further Decommissioning of the Plum Brook Reactor Facility, NASA Lewis Research Center, July 1978
4	Final Radiological Survey for the Release of Buildings 1121, 1142 and Structure 1156 at the Plum Brook Reactor Facility, NASA Lewis Research Center, November 1980
5	Environmental Report, Plum Brook Reactor Dismantling, Amendment 1, NASA Lewis Research Center, February 1981
6	Memorandum from Teledyne Isotopes to General Manager of Plum Brook Operations – Subject: Off-Site Radiological Environmental Monitoring Around PBRF, June 1981
7	Letter from Teledyne Isotopes, John Ross, General Manager, Plum Brook Operations to Mr. Earl C. Boitel, Jr. PBRF Manager, NASA Lewis Research Center; Re: Additional Information regarding Water Infiltration of the PBRF-HRA Structure, May 16, 1985
8	Environmental Compliance Audit Report, Plum Brook Station, Sandusky, Ohio, NASA Lewis Research Center, April 1986
9	An Evaluation of the Plum Brook Reactor Facility and Documentation of Existing Conditions, Study Organization, NASA Lewis Research Center, December 1987
10	An Evaluation of the Plum Brook Reactor Facility and Documentation of Existing Conditions, (Volumes 1, 2,3 and 6 a 6 Volume Series), NASA Lewis Research Center, December 1987
11	Environmental Resources Document, NASA Lewis Research Center, Cleveland, Ohio, NASA Lewis Research Center, August 1990
12	Plum Brook Station, Preliminary Assessment, Volume I-IV, NASA Lewis Research Center, June 1991
13	NASA Plum Brook Station Underground Storage Tank Corrective Actions, Remedial Investigation/Feasibility Study, Phase I Report, NASA Lewis Research Center, November 1991
14	Site Inspection Report, Plum Brook Station, Sandusky, Ohio, Volume I-II, NASA Lewis Research Center, January 1994
15	NASA Plum Brook Station Reactor Facility Risk Assessment, Final Draft, NASA Lewis Research Center, February 1994
16	NASA Plum Brook Garage and Maintenance Area, Final Report, NASA Lewis Research Center, February 1994
17	RCRA Closure Plans, Plum Brook Ordnance Works, Sandusky, Ohio, U.S. Army Corps of Engineers, Huntington District, February 1994
18	County and City Data Book, 1994 – A Statistical Abstract Supplement, U.S. Department of Commerce, August 1994
19	Biological Inventory of Plum Brook Station, 1994, NASA Lewis Research Center (Office of Environmental Programs), February 1995

Ref. No.	Document
20	Draft Records Review Report, Plum Brook Ordnance Works Sandusky, Ohio, U.S. Army Corps of Engineers, Huntington District, April 1995
21	Site Management Plan, Plum Brook Ordnance Works, Sandusky, Ohio; Part B, Areas of Concern, U.S. Army Corps of Engineers, Huntington District, September 1995
22	Closure Work Plan, Reactor Area NASA Plum Brook Station, Sandusky, Ohio, NASA Lewis Research Center, September 1995
23	Environmental Justice Implementation Plan For NASA Lewis Research Center, NASA Lewis Research Center, April 1996
24	Soil Screening Guidance: Technical Background Document, Second Edition, EPA/540/R95/128, US Environmental Protection Agency, May 1996
25	Records Review Final Report, Plum Brook Ordnance Works, Plum Brook Station/NASA, Sandusky, Ohio, U.S. Army Corps of Engineers, Huntington District, April 1997
26	Red Water Ponds Focused Remedial Investigation Final Report for Plum Brook Ordnance Works, Plum Brook Station/NASA, Sandusky, Ohio, U.S. Army Corps of Engineers, Nashville District/Huntington District, April 1997
27	Recommended Approach to the Update of the 1985 PBRF Engineering Study; Phase I, NASA Plum Brook Operations, NASA Glenn Research Center, December 1997
28	Smear Survey Record of Cold Retention Pond, NASA Lewis Research Center, February 1998
29	Second Quarterly Groundwater Level Measurements and First Semi-Annual Groundwater Sampling Event, Site-Wide Groundwater Investigation, Former Plum Brook Station/NASA, Sandusky, Ohio; Revision 0, U.S. Army Corps of Engineers, Nashville District, May 1998
30	Smear Survey Record of Cold Retention Pond, NASA Lewis Research Center, October 1998
31	Draft, Refined Analysis of Alternatives for License Termination of the Plum Brook Reactor Facility, NASA Lewis Research Center, November 1998
32	NASA/Lewis Plum Brook Reactor Facility, Confirmatory Survey, Volume I-II, NASA Lewis Research Center, November 1998
33	Site Investigation of Acid Areas, Former Plum Brook Ordnance Works, Sandusky, Ohio; Revision 1, U.S. Army Corps of Engineers, Nashville District, December 1998
34	Draft Report, Risk Assessment and Direct-Push Investigation of Red Water Pond Areas, Former Plum Brook Ordnance Works, Sandusky, Ohio, Volume; 1, Revision 1, U.S. Army Corps of Engineers, Nashville District, March 1999
35	Final Summary Report, Site-Wide Groundwater Monitoring (1997-1998), Former Plum Brook Ordnance Works, Sandusky, Ohio; Volume 1, Revision 1, U.S. Army Corps of Engineers, Nashville District, June 1999
36	Limited Site Investigation Draft Final Report,Former Plum Brook Ordnance Works, Pentolite Area Waste Lagoons, Sandusky, Ohio, U.S. Army Corps of Engineers, Louisville District, August 1999
37	Sediment Sample Data from October 1999, NASA Lewis Research Center, October 1999
38	Decommissioning Plan for the Plum Brook Reactor Facility; Revision 0, NASA Glenn Research Center, December 1999
39	Amended Closure Plan, Garage and Maintenance Area, Building 7121 and Building 7131, Internal Draft, NASA Glenn Research Center, December 1999
40	Reactor Area Building 1131, Amended Closure Plan, NASA Glenn Research Center, March 2000
41	Letter with attachment; Re: Laboratory Validation, Final Results of Analyses Conducted of 12 Soils Samples collected by NASA on the Plum Brook Reactor Facility site in October 1999, U.S. Army Corps of Engineers, Huntington District, March 2000
42	Amended Closure Plan, Reactor Area, NASA Plum Brook Station, Sandusky, Ohio, Volume I, NASA Glenn Research Center, March 2000
43	Procedures Manual, Protected Safe Storage Mode, Plum Brook Reactor Facility, NASA Glenn Research Center, March 2000
44	Office of Safety and Assurance Technologies, Plum Brook Reactor Facility Decommissioning Project Plan, NASA Glenn Research Center, April 2000
45	Limited Site Investigation Final Report for the former Plum Brook Ordnance Works, Ash Pits Numbers 1 and 3, Sandusky, Ohio, U.S. Army Corps of Engineers, Louisville, District, July 2000

Ref. No.	Document
46	Limited Site Investigation Final Report for the former Plum Brook Ordnance Works, Garage Maintenance Area, Sandusky, Ohio, U.S. Army Corps of Engineers, Louisville, District, July 2000
47	Fluorescent Light Fixtures and Battery Summary (PCB Ballasts), Plum Brook Reactor Facility, NASA Glenn Research Center, August 2000
48	General Engineering Laboratories – Certificate of Analysis (Fission and Activation Products – Hot Cell Swipes, July 2000), NASA Glenn Research Center, August 2000
49	NASA Plum Brook Reactor Facility Decommissioning and Decontamination Pre-Design Investigation Plan, NASA Glenn Research Center, August 2000
50	NASA Plum Brook Reactor Facility Decommissioning and Decontamination Pre-Design Investigation Soil Sampling Analytical Data, NASA Glenn Research Center, August 2000
51	Water Sample Record, July and August 2000 Samples, NASA Glenn Research Center, September 2000.
52	SAIC-FASS Team Asbestos Containing Materials/Lead Based Paint/PCB Survey Plum Brook Reactor Facility Buildings, NASA Glenn Research Center, September 2000
53	Environmental Assessment for the Decommissioning of the Plum Brook Reactor Facility, Plum Brook Station, NASA Glenn Research Center, October 2000
54	Memo: Risk-Based Concentration Table, United States Environmental Protection Agency, Region III, October 2000
55	Conversation with Dave Stith regarding naturally occurring BTEX compounds in limestone in Sandusky, Ohio area, Department of Geochemistry, Ohio Division of Geological Survey, November 2000.
56	Conversation with Dave Stith regarding background levels of heavy metals in Sandusky, Ohio area, Department of Geochemistry, Ohio Division of Geological Survey, February 2001.

2.1.2 Inspections of Properties Conducted and Personnel Contacted

The specific buildings/areas at PBRF that were inspected during the site visit and the personnel interviewed/contacted are shown in Tables 2.1.2-1 and 2.1.2-2, respectively.

Table 2.1.2-1. *Facilities Inspected*

Building Number	Facility Description
Main Buildings	
1111	Reactor Building
1112	Hot Laboratory Building
1131	Service Equipment Building
1132	Fan House Building
1133	Waste Handling Building
1134	Primary Pump House
1136	Compressor Building
1141	Office and Laboratory Building
Support Buildings and Structures	
1135	Gas Service Building
1156	Water Tower
1157	Cooling Tower Platform
1158	Sludge Basins
1159	Cold Retention Basins
1160	Hot Retention Area
1158	Precipitator Tank
1161	Substation
1191	Security Building
1192	Water Effluent Monitoring Station
1195	Cryogenic and Gas Supply
1196	Gas Storage Structure

Table 2.1.2-2. *Personnel Interviewed/Contacted*

Name	Position/Subject Area Specialty	Years at PBRF
Hank Pfanner	Reactor Manager/General Operations, Site History	1963-present
Don Young	Radiation Technician/General Operations, Site History	1963-present
Lee Early	Lab Technician and Maintenance/Lab Operations, Site History	1965-present
Len Homyak	Project Manager/General Operations, Site History	1962-1995
Timothy Polich	Decommissioning Project Manager/ General Operations, Site History, Environmental Sampling	1999-present
Keith Peecook	Construction Manager/ General Operations, Site History, Environmental Sampling	1995-present

3.0 PLUM BROOK REACTOR FACILITY SITE HISTORY

This section describes the history of the PBS, including the 11 ha (27-acre) parcel that is now the PBRF and the adjacent areas within the scope of this EBSR. Also provided is a technical description of the overall facility processes when the reactor was active. This includes a description of each building/structure at the facility and its purpose and activities carried out there. Utilities present, waste generation and handling practices, and environmental monitoring conducted are also described.

3.1 PAST USES

The original PBS site was acquired by the Department of Defense (DoD) in 1940 and consisted of approximately 9,010 acres. Prior to 1940, it was suspected that this land and the area surrounding it had only been used for either agriculture or was undisturbed open fields or woodlands. In order to verify the suspected lack of development of the area prior to 1940, several avenues were pursued. Historical topographic and land use maps were reviewed, and PBRF personnel who grew up in the area were interviewed. In addition, there are no Sanborn Fire Insurance Maps for the area (discussed further in Section 4.8.7). This indicates that the area was not developed. Based on these data, it is apparent that prior to 1940 the area that became the PBS was privately owned and was used for agriculture, or remained undeveloped fields or wooded areas. According to Mr. Hank Pfenner, the current Reactor Manager whose family owned the land comprising what is now the PBRF prior to 1940, the land was only used for agriculture until its purchase by the DoD.

In the 1941, the Plum Brook Ordnance Works (PBOW) was established and the U.S. Army contracted with the Trojan Powder Company to manufacture TNT, DNT and pentolite at the PBOW. Production began on December 16, 1941 and continued through late 1945, ceasing two weeks after V-J Day. During this production period, over 900 million pounds of these materials were manufactured at PBOW. After the operation ceased, the area was turned over to the Army Ordnance Department and was renamed Plum Brook Depot and used for ammunition storage (Ref. #19).

During the PBOW era, the area comprising the western half of the current PBRF was known as the Pentolite Area. The high explosive pentolite was manufactured in this area. The wastewater generated as part of this process was disposed of in the Pentolite Area Waste Lagoons, which were located in what is now the southwestern portion of the PBRF. Historic aerial photos of the Pentolite Area and waste lagoons are provided in Appendix B.

The wastewater generated from the pentolite manufacturing process potentially contained nitroaromatics including pentaerythritol (PE), pentaerythritol tetranitrate (PETN), trinitrotoluene (TNT), and the solvent acetone.

Included in the adjacent areas within the scope of this EBSR are five PBOW sites located south of the former Pentolite Area: the Pentolite Road Red Water Ponds, the Garage Maintenance Area, the Rail Car Unloading Area/Sellite Area, Ash Pit #1 and Acid Area #3. These areas and the activities carried out there are described in detail in Section 4.8 of this EBSR.

The PBOW was placed in standby condition from 1945 to 1946. During this time, the Army conducted decontamination and decommissioning (D&D) of many of the buildings and structures associated with the manufacturing of ordnance (Ref. #12). D&D included removal and relocation of all explosives to burning grounds for incineration. Where possible, remaining structures and buildings were burned in place. Decontamination of pentolite manufacturing lines was halted during the last quarter of 1945, and it was estimated the 65% of the necessary decontamination of the PBOW had been completed by December 1945 (Ref. #14).

No information is available regarding decontamination of surrounding soils in the Pentolite Area or the removal of the waste lagoon structures (Ref. #22). However, during construction of the PBRF the entire area was filled and graded; the waste lagoon structures were likely removed at that time. A memo dated 1958 states that the “Pentolite Area of approximately 117.3 acres was decontaminated, demolished, and cleared for use as the Lewis Laboratory Reactor Facility” (Ref. #22).

In December 1945, custody of the PBOW was transferred from the Trojan Powder Company to the U.S. Army Ordnance Department, and the U.S. Army Corps of Engineers (USACE) assumed responsibility for maintenance and custodial duties at the PBOW from January 1 through June 30, 1946. In August 1946, PBOW was transferred to the War Assets Administration. Additional decontamination efforts were undertaken by Ravena Arsenal from 1954 to 1958 (Ref. #19).

In 1956, the National Advisory Committee for Aeronautics (NACA) began leasing sections of PBS from the Army. An agreement was made in 1956 for a lease of 500 acres of the north portion of the site to construct and operate the PBRF. The PBRF was designed and built from 1957 through 1961, and the facility was tested until April 1962 when full power operation began.

In 1958, NACA became the National Aeronautics and Space Administration (NASA). By 1963, approximately 6,400 acres of the PBOW had been acquired by NASA for various aerospace research activities, plus an additional 2,000 acres to serve as a buffer zone. Research and test activities were conducted by NASA throughout the site from the 1960s and early 1970s.

In 1978, NASA declared approximately 2,150 acres of land as excess. The Perkins Township Board of Education uses 46 of the excess acres as a bus transportation center. Much of the remaining excess property was reclaimed for farmland. NASA also transferred Parcel #59 to the General Services Administration (GSA) in 1978 for subsequent disposal. The efforts of the GSA to dispose of the property have been futile largely due to the presence of the wastewater ponds resulting from PBOW activities. The current site consists of approximately 6,400 acres.

NASA controls the land known as the PBS through ownership of title, use of easements, leases, permits, and ownership of development rights.

3.2 DESCRIPTION OF THE FACILITY WHEN IT WAS ACTIVE

The PBRF is located within an 11-ha (27-acre) fenced area on the PBS and includes the following facilities and areas (see Figure 1.1-2):

- A Reactor Building (Building 1111) with a 60-megawatt research test reactor and 100-kilowatt swimming-pool type thermal mock-up reactor

- A seven cell Hot Laboratory complex (Building 1112)

- Reactor and laboratory operations support facilities that include the Reactor Office and Laboratory Building (Building 1141), Primary Pump House (Building 1134), Fan House (Building 1132), Waste Handling Building (Building 1133), Hot Retention Area (1155), Cold Retention Area (1154), Hot and Cold Pipe Tunnels, and the Cooling Tower (#1152) which was removed in the early 1980s

- The effluent drainage system, which includes catch basins/drainage culverts, the Water Effluent Monitoring Station (Building #1192), which drains into Pentolite Ditch outside the PBRF fence, and the Emergency Retention Basin

- General support facilities which include the Reactor Services Equipment Building (Building 1131), Substation (#1161), and the Security Building (#1191)

- Raw water treatment facilities including the Water Tower (#1151), Precipitator (#1157), Sludge Basins (#1153), and Drying Basins located just outside the fence in the northern portion of the PBRF

- Cryogenic support facilities including the Cryogenic and Gas Supply Farm and Building (#1195 and #9837 – both removed), the Gas Storage Structure (#1196 - removed), Compressor Building (#1136), and the Gas Services Building (#1135).

During its operating life, the PBRF was used to perform nuclear irradiation testing of fueled and unfueled experiments for space program applications. The facility was designed to segregate processes involving radioactive materials (“hot” areas or equipment) from all other processes and operations (“cold” areas). As a result, hot areas were contaminated with radionuclides. A brief description of the facilities/areas and their function, during the period of operation of the PBRF, is provided below. Process flow charts for the various systems can be found in Appendix E.

Major Facilities

Reactor Building (Building 1111)

The Reactor Building is a four-story structure (two basements and main and second floor levels) that houses the 9-foot diameter, 31-foot high reactor tank encased in a concrete biological shield varying in thickness of up to 2.7-m (9-ft). It consists of the following:

- Reactor tank and internal components
- Primary cooling water and primary cooling shutdown systems
- Biological shield
- Quadrants and canals and pump-out, recirculation, and drain systems
- Reactor building rooms
- Hot drains, sumps, pumps, and valves

The core of the research reactor contains uranium/aluminum alloy fuel elements with aluminum alloy arranged in a 3x9 lattice with five fueled cadmium controls rods in the center row of the lattice. The reactor was light-water cooled and moderated with a primary beryllium reflector and secondary water reflector. Experiments were inserted using two horizontal through tubes, six horizontal beam tubes, and two vertical experiment tubes all made of aluminum alloy.

The reactor tank and concrete biological shielding are surrounded by four quadrants (Quadrants A–D), three (A, C, and D) of which could be flooded with water for additional biological shielding and one which served as a dry area (Quadrant B). The reactor and quadrants are enclosed within a 30-m (100-ft) diameter, 1.9-cm (¾-in) thick steel containment vessel extending from 17-m (56-ft) belowgrade and 16-m (53-ft) abovegrade. A system of canals that were used to move irradiated fuel and targets to and from the reactor tank, fuel storage area, and the adjacent Hot Laboratory (Building 1112) surround the quadrants. The reactor tank was used as a pressurized container for the building and was an important component of the primary cooling water system. The reactor tank also supported the reactor core, reactor controls, and experimental facilities.

The PRBF quadrant and canal recirculation system is a closed loop recirculation system. The quadrant and canal recirculation system were used to recirculate water from Quadrants A, C, and D through two filter units and two mixed resin deionizers located in the Fan House. The water was recirculated to maintain clean and optically clear quadrant water.

The quadrant and pump-out system were used to pump water from Quadrants A, C, and D and Canals E through K into the Cold Retention Basins for storage. This water could be returned through a filter in the Fan House back to the quadrants and canals.

The hot drain system, which consisted primarily of sumps, pumps, and valves, served as the drainage collection system for all wastewater that came from a radioactively contaminated area.

Primary cooling water piping, embedded in concrete, extends from the reactor tank to the primary pump house (Building 1134). The primary cooling water piping was used to remove heat from the reactor core and transfer the heat to the secondary cooling loop.

The mock up reactor is also located in the reactor building in Canal H. This reactor was used to calibrate fuel elements and other experiment components and to test rigs before insertion in the test reactor.

In addition to the facilities and equipment described above, the Reactor Building contains work space used to set-up experiment assemblies, a personnel decontamination facility, a change room, and a control room for remote operation of experiment rigs. More detailed discussion of the facilities of the Reactor Building is available in the *Decommissioning Plan for the Plum Brook Reactor Facility* (Ref. #38).

Hot Laboratory (Building 1112)

The Hot Laboratory is a two-story structure consisting of a basement and main level and is attached to the south side of the Reactor Building (Building 1111). The hot dry storage area in the Hot Laboratory is the area closest to the reactor building and is a shielded room used to store irradiated reactor and experiment components and tools (e.g., core fuel element handling tools). The hot laboratory also contains seven hot cells, a storage canal, a decontamination room, repair shop area, an office, and work areas.

Reactor and Laboratory Operations Support Facilities

The reactor and laboratory operations support facilities includes both hot and cold facilities. The hot facilities/areas include the Reactor Office and Laboratory Building (Building 1141), Primary Pump House (Building 1134) and associated primary cooling water system, Fan House (Building 1132), Waste Handling Building (Building 1133), Hot Retention Area (1155), Cold Retention Area (1154), Hot Pipe Tunnel, and the effluent drainage system. The cold facilities include the cold pipe tunnel, the secondary cooling water system; the Reactor Services Equipment Building (Building 1131), except for an analytical laboratory; the raw water treatment system, the cryogenic facilities, the Substation (1161), and the Security Building (1191). These facilities are described below.

*Reactor Office and Laboratory Building (Building 1141)***.** This is a three-story building (basement, main and second story level) attached to the west side of the Reactor Building (Building 1111). During the operation of the PBRF, this facility housed offices (e.g., engineering and health physics), repair shops, a first aid facility, and radiochemistry laboratories.

The radiochemistry laboratories in this building analyzed the substances with the highest levels of radioactivity, including the primary cooling water and some materials used in experiments. Solid radioactive waste from these laboratories was placed into closed stainless steel containers for pick-up by health and safety personnel. The low-level solid waste was stored in the Waste Handling Building (1133) until it was shipped for disposal. Liquid wastes generated at these laboratories, including waste chemicals and solvents (including chloroform, carbon tetrachloride, acetone, toluene, trichloroethylene, 1,1,1-trichloroethane, and fuming nitric acid), were disposed of in drains that lead to the Hot Retention Area (Building 1155). In addition, 1,1,1-trichloroethane (brand name NA-500) was stored in 55-gallon drums in the basement of this building.

Primary Pump House (Building 1134). This is a one-story building attached to the eastside of the Reactor Building (Building 1111). It contains the reactor primary cooling water pumps, heat exchangers, and ion exchangers for the primary cooling water system, primary coolant strainers, resin pits, and a hot sump.

The primary cooling water system consists of four loops: the main loop, the by-pass cleanup loop, the instrument and test hole cooling loop, and the shutdown loop. The main loop contained 26,000 gallons of deionized water and is connected to the reactor tank. The by-pass cleanup loop is a secondary loop on the main loop used to control the purity of the water in this system. There are two mixed bed deionizers that each contain 41 cubic feet of mixed bed resin that removed radioactive ions from the cooling water. The typical life of the resin bed was 8 months. Spent resin was stored at the Waste Handling Building (1133) for shipment to the disposal facility. The instrument cooling loop supplied cooling water to the test holes and the shutdown loop was used for decay heat removal after shutdown.

Fan House (Building 1132). This is a two-story building that houses the filtration and exhaust systems for all hot areas at the PBRF, including the Reactor Building and the Hot Laboratory complex. In the Fan House, room air from PBRF buildings was filtered through absolute filters and exhausted through the Fan House stack. Air emissions at the stack were monitored according to the requirements in the facility's Atomic Energy Commission (AEC) license; no exceedances of the Maximum Permissible Concentrations (MPCs) occurred during operation of the PBRF. Monitoring equipment included: a gaseous activity monitor and scintillation detector, a radioiodine activity monitor filter and scintillation detector, and particulate activity monitor filter and GM tube, and a gross beta-gamma GM tube read out.

Waste Handling Building (Building 1133). This is a two-story building that contains the liquid waste evaporator system, laundry equipment, waste packaging equipment, a small analytical laboratory, and low-level solid waste storage facilities. Low-level solid radioactive waste stored here included personal protective equipment, air filters from the air handling system, and other miscellaneous solids such as rags, etc. Liquid effluent from the laundry equipment was piped to the hot drain system. The evaporator was used to treat liquids from the Hot Retention Area, described below; sludge from the evaporator was stored in this building and shipped offsite for disposal with the other low-level waste at the radioactive waste disposal facility in Maxey Flats, Kentucky.

Hot Retention Area (1155). This area has eight 230,000-L (60,000-gal) and four 28,000-L (7,500-gal) steel underground storage tanks. This area is located south of the Fan House and during operation of the PBRF facility received radioactively contaminated water from the hot drain systems. All radioactively contaminated water was sent to the larger tanks, and the smaller tanks were used as holding tanks. The contaminated water was treated, monitored and then discharged to the Cold Retention Area (1154), the quadrant and canal recirculating system, or the Water Effluent Monitoring Station (Building 1192).

Cold Retention Area (1154). This area has two 1,900,000-L (500,000-gal) below-grade storage basins that were used to store low-level radioactive water primarily from the quadrants and canals in the Reactor Building.

Cold PipeTunnel. This contains the piping system that was used during PBRF operation to transport uncontaminated process water from the Reactor Water Tower (1151) to the Reactor Services Equipment Building (Building 1131) and then onto the Primary Pump House (Building 1134).

Secondary Cooling Water System. The Secondary Cooling Water System is composed of five loops, which contained a total of 225,000 gallons: the main, auxiliary, test, filter, and shutdown loops. This system was used to remove heat from the Primary Cooling Water System.

Effluent Drainage System

Drainage System

The drainage system for the PBRF is a series of open ditches, covered culverts, and catch basins used for collecting and transporting all liquid effluent from the 11-ha (27-acre) PBRF from its source to the WEMS. This includes surface water and roof-top runoff, building sump discharges, and during operation, low-level liquid wastes.

Water Effluent Monitoring Station (Building 1192)

The Water Effluent Monitoring Station (WEMS) was used to monitor all PBRF liquid effluents for radioactivity prior to being discharged to Pentolite Ditch. The station is located in the southeast corner of the PBRF and is comprised of a metal building and concrete trench with metal sluice gates and flumes. Effluent flow rate and radiological quality was monitored continuously at the WEMS. If any permitted limits were exceeded, the sluice gates would automatically shut and the water would be diverted to the Emergency Retention Basin, described below.

Emergency Retention Basin

The Emergency Retention Basin is a 76x107-m (250x350-ft), 38 million-L (10 million-gal) aboveground, brown clay earthen-diked basin located in the southeast corner of the PBRF. It was used as emergency storage for radioactively water that exceeded the allowable discharge criteria and was used several times during the operation of the PBRF.

Pentolite Ditch

The Pentolite Ditch received all water discharged from the WEMS during PBRF operation. The ditch is located south of Pentolite Road and flows from the area of the WEMS approximately 2,750-ft eastward to Plum Brook.

General Support Facilities

Reactor Services Equipment Building (Building 1131). This is located east of the Primary Pump House and contains the water processing equipment, air compressors, boilers, electrical control equipment, diesel generators for emergency electrical power, and the health physics radiochemistry/analytical laboratory. All areas but the latter were cold areas. Samples analyzed in the laboratory were environmental samples collected as part of the extensive monitoring program carried out during operation of the PBRF. Soil, water, air, crop, and animal tissue samples were collected and analyzed periodically to ensure that the PBRF was in compliance with AEC permit limits. In addition, 1,1,1-trichloroethane (brand name NA-500) was stored in 55-gallon drums in this building.

Substation (Building 1161). Electrical service to the PBRF enters the facility at the substation. Step-down transformers are located here.

Security Building (Building 1191). This building was and is used strictly as the ingress/egress point to the PBRF. Monitoring equipment, including personnel scanning equipment, is used/stored here. All personnel exiting the PBRF were/are screened for radiological contamination prior to exiting the facility.

Raw Water Treatment Facilities

All these facilities were cold facilities and treated water to be used in the reactor operations. Domestic drinking water was supplied by the local municipal water authority and was distributed in an isolated system. An engineering drawing of this system is provided in Appendix D.

Water Tower (Building 1151). Raw water from Lake Erie was stored in this structure prior to its release to the treatment facilities described below. Approximately 1 million gallons per day of water was used while the PBRF was active.

Precipitator (Building 1157). Raw water from the water tower flowed directly to the precipitator (a 42-foot diameter, 125,000-gallon unit), where it was treated with lime-alum to precipitate metals and make process water. Chlorine and possibly an algaecide or similar chemical was also added. Some of this water was then diverted to the Secondary Cooling Water System. The remaining water then continued on in the process water system to gravity-type sand filters. Water was then directed either to the Cooling Tower (Building 1152) where it was further treated with an antifoulant, to various auxiliary systems, or to the deionized water system. Deionized water was used in the hot areas, primarily the Primary Cooling Water System. Sludge from the precipitator was directed to the Sludge Basins, described below.

Sludge Basins (Building 1153). These basins (2) are approximately 15 m x 9 m (50 ft x 30 ft) x 3 m (9 ft) deep and received the sludge from the precipitator. When they approached capacity, the material was pumped to the Drying Basins located in the northernmost portion of the PBRF.

Drying Basins. As mentioned above these areas (2), each approximately 30 m x 30 m (100 ft x 100 ft) in size (the depth is unknown, but is assumed to be shallow – 0.3 – 0.6 m [1-2 ft]), received sludge from the Sludge Basins when they approached capacity. The frequency of this is unknown. From the name, it can be assumed that the sludge was allowed to dry in the Drying Basins. It is not known if the dried sludge was ever cleaned out of the Drying Basins.

Cryogenic Support Facilities

In order to better simulate conditions in space for testing of materials in the reactor, it was equipped with a cryogenic loop. These facilities were also cold (non-radioactive) facilities.

Cryogenic and Gas Supply Farm and Building (Buildings 1195 and 9837). This area was where the helium gas supply was stored. The building was removed during shutdown of the PBRF.

Gas Storage Structure (Building 1196). This structure was used to hold the recovered liquid helium after it had exited the reactor facility. It was removed during shutdown of the PBRF.

Compressor Building (Building 1136). Compressors used to compress the helium gas are housed in this building.

Gas Services Building (Building 1135). This building contains gauging equipment used to monitor the pressure of the cryogenic system.

Environmental Monitoring

Point source air and water monitoring conducted at the PBRF during operation was discussed above in the sections on the Fan House and the WEMS. Other environmental monitoring was conducted at the facility and at locations outside the PBS boundaries. At the PBRF, the Remote Area Monitoring System used several types of detectors to monitor radioactivity up to 100 locations within the facility.

Airborne activity (particulate and gaseous) was monitored both within the buildings and outdoors within the fenced area. Water in the canals and quadrants and other areas was monitored for beta-gamma radiation, while direct radiation measurements were taken in various areas with neutron monitors, pulse detectors, and G-M tubes for beta-gamma radiation. If any monitors detected levels above allowable limits, warning lights were illuminated on a display located in the Health-Safety Operations Office in Building 1141 (see photo in Appendix C).

In addition to on-site monitoring, samples of air, soil, fallout/precipitation, surface water, vegetation, and animal tissue were collected periodically within an approximately 5-mile radius of the PBRF.

4.0 SUMMARY OF DATA FOR ON-SITE PROPERTIES

This section describes the current activities carried out at the PBRF, and the current environmental setting and condition of the area. Also discussed are the community relations efforts during the Decommissioning Project, environmental justice, and the categorization of the property according to the ASTM standard. Finally, the adjacent properties are discussed with regard to the potential for contamination at those areas to migrate to and affect the PBRF.

4.1 CURRENT ACTIVITIES

The PBRF has been inactive since 1973 when the reactor fuel was removed and the facility was put into "standby" mode. In 1979 the status was changed to "mothballed" and the PBRF was put into protected safe storage mode. As part of the NRC license requirements, NASA personnel prepared a Procedures Manual that specifies the activities necessary to safely maintain the facility in its current status. The following procedures are detailed in the manual:

- Emergency;
- Health Physics;
- Response to Abnormal Conditions;
- Administrative; and
- Operations and Maintenance.

Activities at the site currently consist primarily of Operations and Maintenance procedures such as routine inspections and security checks (3 shifts per day). A complete discussion of these activities is beyond the scope of this document. Discussed below are ongoing activities at the PBRF that are environmentally related.

In order to keep the reactor tank in an inert environment, dry nitrogen gas is purged through the tank and vented to the atmosphere via the exhaust stack at the fan house (Building #1132). Because the tank is radioactive, it emits decay products, primarily tritium (H-3). The stack emissions are monitored continuously and compared to the Maximum Permissible Concentrations (MPCs) allowed under the current NRC license. No exceedances of the MPCs have occurred.

Sump pumps are located in the basements of the major buildings at the PBRF to prevent groundwater infiltration into the buildings. This water is discharged to the drainage system leading to the Water Effluent Monitoring Station (#1192), then it drains to Pentolite Ditch and on to Plum Brook (see Sections 4.2.2.2 and 4.2.2.4 for a complete discussion on surface water and process water, respectively). During the site visit, discharge from the sump pumps into the Water Effluent Monitoring Station was approximately 5-7 gallons per minute. NASA personnel stated that this is approximately the average flow rate. This is the only water discharged from the PBRF, other than storm water. Storm water is routed through catch basins and into the same drainage system leading to the Water Effluent Monitoring Station, so during times of rain the discharge into the monitoring station increases proportional to the amount of rainfall.

Environmental monitoring is conducted quarterly, in accordance with the NRC license. Table 4.1-1 shows the locations and media sampled.

TABLE 4.1-1.—*Quarterly Environmental Sampling Media and Locations*

Media	Location
Water	• Cold Retention Basins (#1154) • 1 of the 4 deep wells surrounding the Reactor Building (#1111) • Water Effluent Monitoring Station (#1192) • Emergency Retention Basin Sump (if water is present)
Water/Sediment	• Plum Brook Downstream of Pentolite Ditch (1 location) • Plum Brook Upstream of Pentolite Ditch (1 location) • Pipe Creek - Background Sample (1 location)
Sediment	• Pentolite Ditch (4 locations between WEMS outfall and Plum Brook)
Air	• Thermoluminescent Detector (TLD) inside Building 1111 (4 locations); changed once every quarter • TLD outside on PBRF fence (4 locations – N, S, E, W); changed once every quarter • TLD in Hot Laboratory (Building #1112) (3 locations); changed once every quarter • TLD outside PBRF fence, on Plum Brook Station fence (4 locations – N, S, E, W); 24-hour test once per quarter • Air samples at PBRF fence (5 day duration, once per quarter)
Swipe/Direct Readings	• Radiation surveys of all zoned areas

Another environmental monitoring activity occurring at the PBRF concerns radon gas in the Containment Vessel. Monitoring equipment runs continuously; this is discussed in detail in Section 4.2.15.

4.2 ENVIRONMENTAL SETTING

4.2.1 Land Use

Plum Brook Station is located primarily in Perkins and Oxford townships and covers approximately 2,950 ha (6,400 acres). Most of the land at Plum Brook Station consists of forestland and open fields, and the areas surrounding the Station are primarily rural and agricultural (Ref. #53).

The PBRF encompasses 11 ha (27 acres) in the northern portion of the Plum Brook Station. The area adjacent to the PBRF to the north of the facility is a wooded area maintained by NASA as a buffer zone between the PBRF and the residences along Bogart Road, located approximately 1,500 feet north of the northern edge of the PBRF. The adjacent areas south, east, and west of the PBRF currently consist of open fields and forestland. The immediate area has changed little from that shown in the aerial photos provided in Appendix A.

4.2.2 Water Quality and Management

Current conditions related to water quality and management are discussed below for groundwater, surface water, storm water, process water, and sewer systems. Water quality and management issues concerning the facility when it was active were discussed in Section 3.2.

4.2.2.1 *Groundwater*

Plum Brook Station is underlain by a shallow overburden aquifer and deeper bedrock aquifers. Two principal bedrock aquifers underlie Plum Brook Station. A fractured limestone aquifer occurs in the western portion of Erie County, and groundwater flow in this aquifer is to the north. The PBRF overlies this limestone bedrock aquifer. Wells completed in this aquifer have yields ranging from 19 to 95 liters (5 to 25 gallons) per minute (Ref. #12).

Unconsolidated deposits of glacial origin overlie the bedrock aquifer and comprise the overburden aquifer. The thickness of the overburden ranges from less than 1.5 meters (5 feet) to greater than 8 meters (25 feet). The overburden is the thickest in the vicinity of the PBRF where it is thought to fill in a low in the underlying bedrock surface (Ref. #31).

There are eleven overburden monitoring wells at the PBRF. In addition, four bedrock monitoring wells were installed near the Reactor Building (#1111) when the facility was constructed. See Figure 4.2.2.1-1 for the locations of the wells at the PBRF.

A groundwater investigation is being conducted under the *Resource Conservation and Recovery Act* (RCRA) program in the PBRF area at the former underground storage tank (UST) location shown on Figure 4.2.2.1-1. Three USTs were removed from a common excavation near Building 1131 in the vicinity of the PBRF in 1989 and groundwater remediation has been proposed (Ref. #42). These USTs are further described in Section 4.2.13, Storage Tanks and Pipelines.

The elevation of the groundwater surface is measured quarterly and the groundwater quality is measured semi-annually as part of an ongoing sitewide groundwater investigation. Groundwater flow in both the bedrock and overburden aquifers in the vicinity of the PBRF is thought to be affected by the eight sump pumps located in this area. The pumping in this area has created a localized cone of depression in the groundwater surface. Water levels in bedrock wells completed in this area have fluctuated as much as 8 meters (25 feet) (Ref. #35).

Nature and Extent of Groundwater Contaminants at the PBRF

As part of the Focused RI conducted at the Pentolite Road Red Water Ponds in 1995, Reactor Well 2 at the PBRF was sampled and analyzed for nitroaromatics, nitrates, VOCs, SVOCs, and metals. The nitroaromatics 3-NT and 3,4-DNT were found at levels of 23 ug/l and 13 ug/l, respectively. Three VOCs were also detected (ug/l): benzene (1.8), ethyl-benzene (1.2), and xylenes (8.0). Only benzene was above the EPA Region III Risk Based Concentration (RBC).

Five groundwater monitoring wells were installed as part of the RCRA actions at the UST location. These wells were sampled for VOCs, SVOCs, pesticides, polychlorinated biphenyls, and metals. Dissolved phase VOCs were detected at concentrations above remediation standards in the overburden aquifer. No contamination was detected in the soils (Ref. #38). The groundwater contamination will be addressed by a pump-and-treat remediation system consisting of one groundwater recovery well shown on Figure 4.2.2.1-1.

4.2.2.2 *Surface Water*

There are no surface water bodies within the 11 hectare (27 acre) PBRF. The closest surface water body is Ransom Ditch, located just west of the PBRF. This feature has been intensively modified for drainage and is characterized by steep banks (2 to 1 slope) vegetated with a mixture of grasses, herbaceous weeds, and shrubs. The stream channel is relatively straight because of past dredging activities. Surface water flow is intermittent in the summer and fall with small isolated pools (Ref. #53).

Also near the PBRF is Pentolite Ditch. This intermittent stream is located just south of Pentolite Road, which is at the southern boundary of the PBRF. As discussed below in Section 4.2.2.3, Storm Water, all storm water from the PBRF is routed to catch basins and through the Water Effluent Monitoring Station which discharges to Pentolite Ditch. Pentolite Ditch joins Plum Brook approximately 850 meters (2,800 feet) downstream of the PBRF. A National Pollutant Discharge Elimination System (NPDES) monitoring station is located on Plum Brook, just downstream of the confluence with Pentolite Ditch. The PBRF sumps are a listed source for the Plum Brook outfall in the existing NPDES permit.

The Water Effluent Monitoring Station includes a metal building and a concrete trench with metal gates and flumes. The trench itself, silt entrapped behind the flumes, and an area of soil adjacent to the trench are radioactively contaminated.

The 1985 characterization survey (Ref. #10) measured contamination in the Water Effluent Monitoring Station building and in the silt in the Water Effluent Monitoring Station trench. The 1998 confirmatory survey (Ref. #32) also measured concrete surfaces in the building and found contamination levels consistent with those measured in 1985. Isotopic analysis of gamma emitters in the 1998 survey (excluding naturally occurring gamma emitters) indicated the dominant nuclides were Cs-137 (4 to 11 pCi/g) and Co-60 (1 to 4 pCi/g). Table 4.2.2.2-1 compares the 1985 and 1998 survey results for the Water Effluent Monitoring Station building.

The Pentolite Ditch received all water from the Water Effluent Monitoring Station. Up to 30 cm (12 in.) of silt and soil in some areas along the Pentolite Ditch are radioactively contaminated. The contamination occurs primarily at the western end (near the Water Effluent Monitoring Station outfall), with a smaller amount near the eastern end (near the confluence with Plum Brook).

TABLE 4.2.2.2-1. —*Summary of Survey Results for the Water Effluent Monitoring Station (Building #1192)*

Building/ Structure	Summary of 1985 Characterization Survey Results	1998 Confirmatory Survey	
		No. of Survey Measurements	Results
Water Effluent Monitoring Station (1192)	• Loose alpha contamination ranging from 0 to 2 dpm/100 cm^2 • Loose beta-gamma contamination ranging from 0 to 48 dpm/100 cm^2 • Direct radiation levels ranging from 0.004 to 0.04 mR/hr	• 8 direct beta measurements • 8 smears	• Three measurements were about 15,000 dpm/100 cm^2 • All others were less than 5000 dpm/100 cm^2

For the 1985 characterization, the Pentolite Ditch was divided into 9.1- × 9.1-m (30- × 30-ft) grids. A contact beta-gamma survey was performed at the center and four surrounding points in each grid. A silt sample was then collected at the center point and a soil sample was collected at the surrounding point that had the highest contamination level. The survey results indicated that portions of the ditch nearest the Emergency Retention Basin (i.e., the west end) and nearest Plum Brook (i.e., the east end) were contaminated with higher levels of contamination than in the other portions of the ditch. Samples from four shallow (3 m [10-ft]) cores indicated that contamination was confined to depths less than 15 cm (6 in).

Sampling indicated that soil from the bottom and the banks of the Pentolite Ditch had average gross beta activities of 40 and 110 pCi/g, respectively.

During the 1998 confirmatory survey, eight sediment samples were collected along the Pentolite Ditch. The analytical results showed that the total activity in the samples ranged from 10 to 30 pCi/g. Most of the activity is from natural K-40; the residual activity from Cs-137 ranged from 2 to 15 pCi/g and from Co-60 from 0 to 1 pCi/g. The 1998 average concentration (about 20 pCi/g) is lower than that measured in 1985 (75 pCi/g). This decrease could be due to several factors, including decay, fewer sample locations, and irregular distribution of the contamination.

4.2.2.3 *Storm Water*

As mentioned above, storm water from the entire 11 hectare (27 acre) is routed to catch basins that lead to the Water Effluent Monitoring Station, which then discharges to Pentolite Ditch. Also as mentioned in Section 3.2, all process water from the facility was routed through this system once radioactivity levels were within permissible standards. This drainage system consists of a series of open ditches, covered culverts, and catch basins (ditches and culverts are shown as dotted lines on Figure 1.1-2). Underground piping and silt deposits in the catch basins are radioactively contaminated.

The 1985 characterization effort (Ref. #10) reported that accumulated silt in the catch basins had gross beta activity ranging from 7 to 330 pCi/g, with an average of 44 pCi/g. Depths and areas of contamination were not reported.

The catch basins were reexamined in the 1998 confirmatory survey (Ref. #32). The beta survey showed that one sample had a maximum concentration of 5000 dpm/100 cm^2, and the remaining samples had an average concentration of less than 1200 dpm/100 cm^2. The 1998 gross beta activity measurements are on the order of 15 to 20 pCi/g, similar to the average 1985 measurements (44 pCi/g). The 1998 sampling effort also showed that the activity in the catch basins is predominantly naturally occurring K-40, at concentrations ranging from 7 to 14 pCi/g. The concentration of Cs-137 and Co-60 ranged from 1 to 11 pCi/g and from 1 to 5 pCi/g, respectively.

4.2.2.4 *Process Water*

Because the PBRF is non-operational, there is no process water at the facility. When the facility was active, however, large quantities of process water were utilized. A complete description of the process water system was provided in Section 3.2.

4.2.2.5 *Sewer Systems*

Because the PBRF is non-operational, the sewer system is not used. In fact, most drains have been blocked to prevent usage. A discussion of the sanitary sewer system was provided in Section 3.2.

4.2.3 Air Quality and Management

Plum Brook Station is located in Erie County, which is in attainment for all National Ambient Air Quality Standards primarily because of the rural character of the area. A 1991 report stated that the Ohio EPA operates one monitoring station for total suspended particulates in the county that consistently in compliance with particulate standards (Ref. #12). Because of the limited operation of facilities at Plum Brook Station, there are limited emissions to the atmosphere and the site is not classified as a major emission source under the Clean Air Act Title V permitting program. There are no permitted emission sources at the PBRF (Ref. #53).

In order to keep the reactor tank in an inert environment, dry nitrogen gas is purged through the tank and vented to the atmosphere via the exhaust stack at the fan house (Building #1132). Because the tank is radioactive, it emits decay products, primarily tritium (H-3). The stack emissions are monitored continuously and compared to the Maximum Permissible Concentrations (MPCs) allowed under the current NRC license. No exceedances of the MPCs have occurred.

Air quality management practices observed when the facility was active were discussed in Section 3.2.

4.2.4 Noise

Noise sources at Plum Brook Station include an airstrip, transient noise blasts from test facilities, construction activities, and traffic noise. The Army Reserves and the Ohio Air National Guard also discharge pyrotechnic devices at Plum Brook Station. None of these activities is a significant noise source (Ref. #53).

Since the PBRF was shut down in 1973 and is currently inactive and uninhabited, there are essentially no noise sources at the facility.

4.2.5 Energy

Electricity is currently available at the PBRF. It is obtained from the Ohio Edison Company's local power grid and enters the PBRF through the substation (#1161). Infrastructure for natural gas service is in place at the facility and is used for facility unit heaters.

4.2.6 Hazardous Materials Management

Because the PBRF is not operational, no hazardous materials are used at the facility; *Emergency Planning and Community Right-to-Know Act* requirements currently do not apply to the PBRF. Hazardous materials management practices when the facility was active were discussed in Section 3.2.

4.2.7 Asbestos Containing Materials, Lead-Based Paint, and PCBs

During the site visit, peeling paint was noticed to be present throughout the PBRF buildings, in addition to material suspect to contain asbestos. A survey for asbestos containing material (ACM), lead-based paint (LBP) and polychlorinated biphenyls (PCBs) was not within the scope of this EBSR because comprehensive surveys for these materials in all buildings at the PBRF were conducted in the summer of 2000. The surveys consisted of a visual inspection and sampling/laboratory analysis for asbestos, lead in paint, and PCB content in both paint and in miscellaneous items; estimates on the total quantities of ACM, LBP, and PCBs at each PBRF building. The accessibility (height) of the material was also noted. The results of these comprehensive surveys are summarized below.

ACM Survey

The materials considered to have asbestos are listed in Table 4.2.7-1. The types, quantities, and locations of ACM by building are detailed in Table 4.2.7-2. Note that the report recommended that all quantities are estimates and should be checked by the Abatement Contractor prior to bidding.

TABLE 4.2.7-1. -—*Materials Considered to Contain Asbestos*

ACM Detected
Fiberglass piping and systems insulation with canvas covered and tar paper (foil) covered fiberglass
All insulated valves, fittings (elbows, tees, etc.), air ducts, service equipment, and vibration cloth
All floor tile, linoleum, and mastics
All base moldings and ceiling tiles or panels (their mastics were acm)
Joint tape used on the cellulose panels in Building #1112 (Reactor Hot Lab), Room 9
All window caulking
All joint areas of drywall
All roof materials under the foam cover
Radioactive exclusion zones not tested, but should be considered suspect ACM
ACM Not Detected
All Plaster and Wall Board (Ceilings)
All Drywall Only

TABLE 4.2.7-2. ––*Type and Quantity of Asbestos Containing Materials by Building*

Building #	Type and Quantity of ACM (SF, LF, Ea.)
1111	45,281 SF (floor tile, linoleum, base molding, roofing, caulking, insulation) 6,818 LF (pipe insulation) 60 Ea. 2" Mudded Fitting 6 Ea. 2.5" Mudded Fitting 224 Ea. 3" Mudded Fitting 213 Ea. 3.5" Mudded Fitting 94 Ea. 4" Mudded Fitting 107 Ea. 4.5" Mudded Fitting 105 Ea. 5" Mudded Fitting 20 Ea. 5.5" Mudded Fitting 44 Ea. 6" Mudded Fitting 85 Ea. 6.5" Mudded Fitting 8 Ea. 7" Mudded Fitting 36 Ea. 8" Mudded Fitting 16 Ea. 8.5 Mudded Fitting 59 Ea. 9" Mudded Fitting 20 Ea. 10" Mudded Fitting 14 Ea. 12" Mudded Fitting 2 Ea. 15" Mudded Fitting 2 Ea. 10" Mudded Valve 5 Ea. 12" Mudded Valve 15 Ea. 16" Mudded Valve 2 Ea. 14" Mag Valve Insulation
1112	20,064 SF (floor tile, base molding, roofing, caulking, wall paneling) 435 LF (pipe insulation) 12 Ea. 3" Mudded Fitting 2 Ea. 6" Mudded Fitting 3 Ea. 7" Mudded Fitting 3 Ea. 9" Mudded Fitting
1131	17,379 SF (floor tile, base molding, ceiling tile, insulation, roofing, miscellaneous packing and gaskets, caulking) 1,616 LF (pipe insulation) 2 Ea. 2.5" Mudded Fitting 70 Ea. 3" Mudded Fitting 54 Ea. 3.5" Mudded Fitting 40 Ea. 4" Mudded Fitting 20 Ea. 4.5" Mudded Fitting 49 Ea. 5" Mudded Fitting 11 Ea. 6" Mudded Fitting 8 Ea. 8" Mudded Fitting 6 Ea. 16 Mudded Valve

Building #	Type and Quantity of ACM (SF, LF, Ea.)
1132	20 SF (insulation, roofing, caulking) 675 LF (pipe insulation) 27 Ea. 3” Mudded Fitting 13 Ea. 3.5” Mudded Fitting 4 Ea. 4.5” Mudded Fitting 11 Ea. 5” Mudded Fitting 7 Ea. 7” Mudded Fitting
1133	11,210 SF (floor tile, base molding, caulking, insulation, roofing, vibration cloth, in boiler and piping system) 1,622 LF (pipe insulation) 6 Ea. 2” Mudded Fitting 149 Ea. 3” Mudded Fitting 94 Ea. 3.5” Mudded Fitting 30 Ea. 4” Mudded Fitting 49 Ea. 4.5” Mudded Fitting 11 Ea. 5” Mudded Fitting 6 Ea. 5.5” Mudded Fitting 5 Ea. 6” Mudded Fitting 6 Ea. 6.5” Mudded Fitting 5 Ea. 7” Mudded Fitting 2 Ea. 10” Mudded Valve
1134	61,143 SF (roofing, insulation, caulking) 398 LF (pipe insulation) 9 Ea. 2.5” Mudded Fitting 25 Ea. 3” Mudded Fitting 40 Ea. 3.5” Mudded Fitting 32 Ea. 4” Mudded Fitting 45 Ea. 4.5” Mudded Fitting 16 Ea. 5” Mudded Fitting 5 Ea. 5.5” Mudded Fitting 3 Ea. 6.5” Mudded Fitting 7 Ea. 9” Mudded Fitting
1136	228 LF (pipe insulation) 4 Ea. 4” Mudded Fitting 1 Ea. 6” Mudded Fitting 4 Ea. 8” Mudded Fitting
1141	102,900 SF (floor tile, base molding, ceiling tile, insulation, roofing, vibration cloth, caulking, drying board) 55,62 LF (pipe insulation) 77 Ea. 2.5” Mudded Fitting 306 Ea. 3” Mudded Fitting 174 Ea. 3.5” Mudded Fitting 137 Ea. 4” Mudded Fitting 109 Ea. 4.5” Mudded Fitting 81 Ea. 5” Mudded Fitting

Building #	Type and Quantity of ACM (SF, LF, Ea.)
1141 (cont'd)	39 Ea. 5.5" Mudded Fitting 4 Ea. 6" Mudded Fitting 18 Ea. 6.5" Mudded Fitting 24 Ea. 7.5" Mudded Fitting 7 Ea. 8" Mudded Fitting 7 Ea. 9" Mudded Fitting 2 Ea. 10" Mudded Fitting 2 Ea. 12" Mudded Fitting 1 Ea. 10" Mudded Valve 18 Ea. 12" Mudded Valve 80 Ea. Tar Coated Hangers
1191	1,200 SF (floor tile)

LF = linear feet; SF = square feet; Ea. = each

LBP and PCBs in Paint Survey

All structural steel (columns, beams, stairs, railings, etc.) should be considered high in lead. The source of the lead seems to be the primer, which is integrated into the steel. The various color paints that are peeling from the structural steel are mainly low in lead content (< 1% by weight), while the primer is intact and integrated into the steel. The Services Equipment Building (#1131); a diesel fuel above ground storage tank immediately north of Building #1131; the Precipitator (#1157); the Water Tower (#1151); and the remaining valve posts at the existing foundation of the Cooling Tower (#1152) also have high lead content (this conclusion for Buildings 1157 and 1151 is based on direct X-ray fluorescence readings, as opposed to laboratory analysis). The paint on Precipitator is damaged and peeling. All four samples in the Primary Pump House (#1134) also tested positive for lead. The majority of paint containing high amounts of lead is gray and peach colored. The quantities and locations of LBP per building are detailed in Table 4.2.7-3.

Paint samples were also tested for PCBs. All of the paint bulk sample analytical results for PCBs were < 50 parts per million (ppm). There was an analytical result of 49 ppm, 50 ppm, and 18 ppm PCB on a peach colored overhead door in Building #1134 (Primary Pump House). Because the analytical results did not have a suitable margin of error to determine this paint to be non hazardous for PCBs (<50 ppm), additional PCB sampling and analysis was conducted on the peach paint. This additional sampling and analysis showed the peach colored paint to be <50.0 ppm in all the PBRF Buildings. Although the additional sampling showed this paint to be non-hazardous for PCBs, the report recommended that the suspect interior peach colored overhead door in Building #1134 be wiped down with a proper cleaning agent to remove any suspect oily material.

The report notes that all peeling paint quantities are estimates due to the deteriorating condition of the paints; quantities of LBP should be checked by the Abatement Contractor prior to bidding.

Results of PCB Survey of Miscellaneous Items

The majority of the PCBs found were in fluorescent light fixtures and batteries. Table 4.2.7-4 details the types and quantities of each per building. There are damaged and leaking fluorescent light fixture ballasts throughout the PBRF Buildings. There are two (2) known PCB Ballast Oil Spill Areas in Building #1141 (Reactor Office and Laboratory Building) on the floor in Rooms #112 and #117.

In the early 1980's all transformers at the PBRF were tested for PCBs. Two were found to contain PCBs at levels greater than 50 ppm. One was located at the substation (#1161) and the other was adjacent to Building 1112. These transformers were removed and properly disposed of according to *Toxic Substances Control Act* (TSCA) regulations.

4.2.8 Waste Management

Since the PBRF was shut down in 1973, there have been no NASA personnel working at the PBRF on an 8-hour per day basis, but only checking on the facility daily. The PBRF is in mothball status. Without personnel regularly on the site, there is no solid waste generated. With the exception of the water supply to the fire hydrant system, all water systems have been abandoned; as stated in Section 4.2.2.5, no wastewater is generated at the PBRF.

The only waste noted during the site visit was 11 55-gallon drums, holding approximately 7 ½ cubic feet per drum, of disposable personnel protective equipment used during the routine environmental sampling and maintenance activities. This waste is considered Class A low-level radioactive waste. NASA personnel stated that a licensed transporter is called periodically to transport the drums to a licensed Class A low-level radioactive waste disposal facility.

Waste management practices when the facility was active were discussed in Section 3.2.

4.2.9 Radioactive Materials Management/Current Radiological Status of the PBRF

Other than residual radioactive contamination at the PBRF, radioactive materials remaining at the PBRF are primarily the reactor tank and the activated equipment remaining in Hot Dry Storage (Building 1112). These areas, as well as other areas that are contaminated by radionuclides, are secure and are only able to be accessed by specially trained personnel. The following discussion of the radiological status of the PBRF is taken primarily from the *Decommissioning Plan for the Plum Brook Reactor Facility*, Rev 0, December 1999 (Ref. #38).

A major characterization survey for the entire PBRF was conducted in 1985, and a confirmatory survey was conducted in 1998. Section 4.2.9.1 summarizes the characterization information from the two surveys. The results from the two surveys indicate that most of the residual radioactivity at the PBRF is confined generally within equipment and piping, with limited environmental contamination. The reactor tank internals and waste in the Hot Dry Storage Area contain most of the radioactivity.

TABLE 4.2.7-3. --*Quantity of Lead-Based Paint by Building*

Location	Paint Color	Est. Quantity Peeling Paint SF, LF, Ea	Accessibility (Elevation) 0-6 ft	6-12 ft	>12 ft	Sample #	Lab Results	Remarks
Building 1111								
Building 1111 elev. -25'-0" Area 21	Green	100 SF	X			N/S: REF. 1131-Pb-006	0.63% by WT. 0.14 mg/cm^2	Equipment
Building 1111 First Floor Area 1 West	Peach	100 SF	X	X		1111-Pb-036	1.2% by WT.	Overhead Door
Building 1112								No Samples with LBP
Building 1131								
Building 1131 Basement Aux. Eq. Room 20	Gray	12 SF, 25 LF	X			1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	South Wall, Piping
Building 1131 Basement Water Treatment Pump Room 21	Gray	75 SF, 15 LF	X			N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Walls, Piping, Valves, Pumps NOTE: Paint is peeling from insulation.
Building 1131 Basement Stairway to Battery Room	Gray	85 SF	X			N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Walls
Building 1131 First Floor Water Treatment Room 13	Gray	135 SF	X	X		N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Wall, Pipe, Equipment
Building 1131 First Floor Control Room 11	Gray	38 SF	X			N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Walls
Building 1131 First Floor Janitor Closet	Gray	4 SF	X			N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Walls
Building 1131 First Floor Office Room 5	Gray	5 SF	X	X		N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Walls
Building 1131 First Floor Boiler Room 15	Gray	26 SF	X			N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Walls
Building 1131 First Floor Boiler Room 15	Peach	70 SF		X		N/S: REF. 1134-Pb-032	2.2% by WT. 1.1 mg/cm^2	Rolling Doors

TABLE 4.2.7-3. --*Quantity of Lead-Based Paint by Building (continued)*

	Paint	Est. Quantity	Accessibility (Evaluation)					
		Peeling Paint						
Location	**Color**	**SF, LF, Ea**	**0-6 ft**	**6-12 ft**	**>12 ft**	**Sample #**	**Lab Results**	**Remarks**
Building 1131 First Floor Boiler Room 15	Green	200 SF	X	X	X	N/S: REF. 1131-Pb-006	0.63% by WT. 0.14 mg/cm^2	Boilers, Equipment and associated Piping
Building 1131 First Floor Elevator Room 17	Gray	3 SF	X			N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Walls
Building 1131 First Floor Engine Room 18	Gray	83 SF	X			N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Walls
Building 1131 First Floor Engine Room 18	Green	100 SF	X			1131-Pb-006	0.63% by WT. 0.14 mg/cm^2	Machinery
Building 1131 First Floor Engine Room 18	Yellow	50 SF			X	N/S	POSITIVE LBP XRF 4.4 mg/cm^2	Crane
Building 1131 First Floor Engine Room 18	Peach		X	X	X	1131-Pb-035	1.6% by WT.	Overhead Door
Building 1131 First Floor Shop and Equipment Area 1	Yellow	50 SF	X			N/S	POSITIVE LBP XRF 4.4 mg/cm^2	Cabinet
Building 1131 First Floor Shop and Equipment Area 1	Green	40 SF	X			N/S: REF. 1131-Pb-006	0.63% by WT. 0.14 mg/cm^2	Cabinet
Building 1131 First Floor Shop and Equipment Area 1	Gray	130 SF	X			N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Walls, Assorted Metal/ Wood Cabinets
Building 1131 Mezzanine WTP- Top of Stairs	Gray	20 SF			X	N/S: REF. 1131-Pb 002	1.00% by WT. 0.34 mg/cm^2	Tank
Building 1131 Exterior	Peach	20 SF	X			N/S: REF. 1134-Pb-032	2.2% by WT. 1.1 mg/cm^2	Overhead Doors
Building 1131 Exterior	Beige	200 SF	X	X	X	N/S	No Lab Positive LBP XRF 2.6 mg/cm^2	Precipitor Tank, Stairs, ETC.
Building 1132								
Building 1132 First Floor Operating Area Room 1	Peach	N/A	X			1132-Pb-038	0.85% by WT.	Entry Door-Eastside

TABLE 4.2.7-3. --*Quantity of Lead-Based Paint by Building (continued)*

	Paint	Est. Quantity	Accessibility (Evaluation)					
		Peeling Paint						
Location	**Color**	**SF, LF, Ea**	**0-6 ft**	**6-12 ft**	**>12 ft**	**Sample #**	**Lab Results**	**Remarks**
Building 1133								
Building 1133 First Floor Boiler Room 14	Green	100 SF	X	X		N/S: REF. 1131-Pb-006	0.63% by WT. 0.14 mg/cm^2	Boiler and Associated Equipment
Building 1133 First Floor Boiler Room 14	Peach	10 SF	X	X		N/S: REF. 1134-PB-032	2.2% by WT. 1.1 mg/cm^2	Doors
Building 1133 First Floor Operating Area Room 1	Peach	30 SF	X	X		N/S: REF. 1134-PB-032	2.2% by WT. 1.1 mg/cm^2	Overhead Rolling Door Note: See Pcb Data
Building 1134								
Building 1134 First Floor Room 8	Peach	50 SF	X	X		1134-PB-032	2.2% by WT. 1.1 mg/cm^2	Rolling Door Note: 49 ppm PCB result
Building 1134 Mezzanine	Gray	25 SF	X			N/S: REF. 1131-PB-002	1.00% by WT. 0.34 mg/cm^2	Walls, Piping, Equipment, and Debris on Floor
Building 1136								
Building 1136 Ground Floor Main Area-Interior	Gray/Various Colors	1000 SF	X	X		N/S: REF. 1131-Pb-002	1.00% by WT. 0.34 mg/cm^2	Paint Debris on Floor Bird Feathers and Feces present
Building 1136 Ground Floor Main Area-Interior	Peach	150 SF	X	X		N/S: REF. 1134-Pb-032	2.2% by WT. 1.1 mg/cm^2	Overhead Rolling Door
Building 1136 Ground Floor Exterior	Gray	50 SF		X		N/S: REF. 1131-Pb-002	1.00% by WT. 0.34 mg/cm^2	East and West Sides around Gutters
Building 1136 Ground Floor Exterior	Peach	150 SF	X	X		N/S: REF. 1134-Pb-032	2.2% by WT. 1.1 mg/cm^2	Overhead Rolling Door
Building 1141								No Samples with LBP

TABLE 4.2.7-4. --*Type and Quantity of PCBs by Building*

Location	Fluorescent Lights Size and Quantity (Each)	Accessibility (Elevation)			Remarks
		0-6 ft	6-12 ft	>12 ft	
Building 1111: 1st Floor & Mezzanine Rooms, Offices, Etc.	8'-62 Ea.; 4'-122Ea.; 1'-6 Ea.		X	X	Batteries: 1-5 Cell Emerg. Light
Building 1112: 1st Floor	8'-35 Ea.; 4'-1 Ea.		X	X	Batteries: 2-5 Cell Emerg. Light
Building 1131: 1st Floor & Mezzanine Rooms, Offices, Labs, Exhaust Hoods, Etc.	8'-7 Ea.; 4'-285 Ea.	X	X	X	Batteries: Water Treatment: Rm 13-(1-3'x6') Batteries Basement: Rm 25-(2-3'x8') Batteries & 1-5 Cell Emerg. Light
Building 1132/1133: 1st Floor & Basement Rooms, Offices, Common Areas, Etc.	8'-20 Ea.; 4'-40 Ea.		X	X	Batteries: 1-5 Cell Emerg. Light
Building 1136: Interior	4'-1 Ea.	X	X		
Building 1141: 1st Floor & 2nd Floor Rooms, Offices, Labs, Common Areas Etc.	8'-174 Ea.; 4'-103 Ea.		X		Batteries: Basement: Rm 7- 1-5 Cell Emerg. Light

Sections 4.2.9.2, 4.2.9.3, and 4.2.9.4 summarize radiological characterization information collected in 1985 (Ref. #10) and in 1998 for the major facilities, contaminated support facilities, and areas expected to be non-radiologically contaminated, respectively.

Residual contamination in the PBRF buildings and environment is from activation products (i.e., H-3 and Co-60) and fission products (i.e., Cs-137 and Sr-90). The background concentrations of these radionuclides are essentially negligible. Radionuclides such as K-40 and Ra-226 are naturally occurring and were measured during the 1985 PBRF characterization. A summary of background radionuclide concentrations is presented in Section 4.2.9.1.

4.2.9.1 *Radiological Characterization of the PBRF*

Two radiological characterization efforts have been conducted at the PBRF. A radiological survey of the PBRF was conducted in 1985. A confirmatory survey was conducted in September 1998 to verify the 1985 results and to provide additional isotopic data to use for estimating doses for license termination. During the 1998 confirmatory survey, buildings that were not expected to require decontamination were surveyed because contamination in these areas could impact decommissioning planning and costs. Two areas of environmental contamination, the Emergency Retention Basin and the Pentolite Ditch were also sampled to confirm the 1985 data.

Most of the inventory at the PBRF is contained in the reactor tank internals and the waste in the Hot Dry Storage Area. Tritium (H-3) is the primary radionuclide of concern in these areas. Outside of the reactor tank and Hot Dry Storage Area, the radionuclides of concern consist of both mixed fission products and activated materials, with the primary radionuclides expected to be Co-60, Cs-137, and Sr-90.

1985 Characterization Survey

The first survey in 1985 (Ref. #10) characterized the buildings and ground surface around the PBRF. The floor and inside wall surfaces at all elevations (including basements) were surveyed in the Reactor Building, the Hot Laboratory, the Waste Handling Building, the Fan House, the Primary Pump House, the hot pipe tunnel, and the Reactor Office and Laboratory Building. The exterior surfaces of the containment vessel dome and roofs were not surveyed because both were resurfaced. The grounds within the fenceline were also surveyed, including soil surfaces, paved areas, and the Pentolite Ditch from the PBRF to Plum Brook.

Background samples were collected and analyzed for eight categories of soil and six buildings that were not affected by plant operations (Ref. #10). The background characterization consisted of measuring gross alpha and gross beta activity levels for all samples and direct radiation levels for a portion of the samples.

For soils, the majority of the samples had gross alpha and gross beta activity levels of 6 to 10 pCi/g and 30 to 40 pCi/g, respectively. Direct radiation levels were approximately 6 μR/hr. These levels are consistent with background levels in other areas of the U.S. One set of background soil samples was collected from a location containing an outcropping of shale. These samples had average gross alpha and gross beta activity levels three times higher than the balance of the background soil samples.

For building surfaces, background characterization included collection of smear samples and static measurement of gross alpha and gross beta activity levels. The average gross alpha activity level was 3 cpm, which is consistent with gross alpha levels reported for similar materials. The average gross beta activity level was 30 cpm, which is lower than gross beta levels reported for similar materials. For typical equipment characteristics, the reported count rates correspond to gross alpha and gross beta activity levels of approximately 25 and 250 dpm/100 cm^2, respectively.

The outdoor area and buildings were surveyed on grids for gross alpha and gross beta activity within the PBRF fenceline. Direct radiation measurements were taken with a micro-roentgen meter. Surface and deep soil samples were analyzed for gross alpha and gross beta activity.

Isotopic analyses were performed on all samples containing significant quantities of radioactive material when those samples represented the systems or structures from which they came. Radioisotopes were identified by gamma pulse height analysis using germanium detectors networked in multichannel analyzer systems. Strontium-90 was analyzed by chemical separation of strontium, holding for ingrowth of the Y-90 daughter and subsequent counting and analysis. Low energy gamma or pure beta emitters, such as Fe-55 or Ni-63, were not measured during the isotopic analysis.

The 1985 characterization survey estimated the radiological inventory of the reactor tank and internals. Three core samples from the biological shield were analyzed for gross alpha and gross beta activity; some portions of the core samples were analyzed for Co-60. Piping and drain systems were also characterized. External contamination and direct dose rates were measured and corrosion films were collected. The water handling systems, including the Hot Retention Area and

Cold Retention Basins, also were analyzed. External contamination and direct dose rates were measured and sludge samples were collected and analyzed.

The major conclusions from the 1985 characterization survey were:

- The majority of the radionuclide inventory at the PBRF is in two locations: (1) the reactor tank and its internals and (2) in stored waste in the Hot Dry Storage Area (in the Hot Laboratory).
- Most of the contamination inside the buildings is inside piping and equipment. Other than the internal piping and equipment contamination, residual contamination in the facilities is limited to locations where piping or equipment has leaked (e.g. the hot pipe tunnel and evaporator in the Waste Handling Building).
- In the reactor tank (exclusive of reactor internals) and the primary cooling system, Co-60 was the dominant gamma-emitting nuclide based on analysis of corrosion film samples. Europium isotopes detected were associated with activation of gadolinium from the injection system during reactor operations. The absence of fission products in the primary cooling system is consistent with the historical information.
- The isotope Co-60 and fission products Cs-137 and Sr-90 were detected in the canal and quadrant drains, hot sumps, resin pits, Hot Retention Area, and Cold Retention Basins.
- Areas of environmental contamination contain Co-60 and fission products.

1998 Confirmatory Characterization Survey

In 1998, a confirmatory radiological survey was conducted at portions of the PBRF to support the planning for decommissioning and license termination activities. For the confirmatory survey, only the easily detected radionuclides were analyzed (by gamma spectroscopy) and quantified. As a result, beta emitters and radionuclides that are difficult to detect (i.e., Sr-90, Fe-55, Ni-63, and other low energy beta emitters) were not identified and quantified. The analysis for the primary gamma emitters (i.e., Co-60, Cs-137, and europium isotopes) was determined to be adequate to verify the 1985 characterization data. Where possible, the sampling techniques and locations used for the 1998 survey duplicated those of the 1985 survey to ensure consistency. However, because exact locations could not be duplicated, the sampling results from the 1998 investigation were compared with the 1985 investigation results primarily to identify any significant differences.

The results from the 1998 confirmatory survey generally confirmed the findings from the 1985 survey. Gamma scans of outdoor areas showed exposure rates of 5 to 10 µR/hr, which are typical for background levels. The 1998 confirmatory survey examined the Emergency Retention Basin, Water Effluent Monitoring Station, Pentolite Ditch, PBRF grounds, PBRF paved areas, catch basins, Cold Retention Area, Reactor Building outside the reactor containment vessel, Reactor Office and Laboratory Building, Service Equipment Building, Fan House, Waste Handling Building, and the cold service tunnels. The areas were surveyed to measure gross beta activity (pCi/100 cm^2) and direct radiation exposure rates. In addition, soil, sediment, and concrete samples were analyzed for gamma-emitting radionuclides.

In general, the 1998 confirmatory survey confirmed the contaminated and uncontaminated areas identified during the 1985 characterization survey. The 1998 confirmatory survey identified six additional contaminated areas: four laboratories (Rooms 207, 209, 210, and 213A) in the Reactor Office and Laboratory Building; an area of contamination on the -4.6-m (-15-ft) basement level of the Reactor Building; and on the PBRF pavement near the entrance to the Reactor Building. Within the Emergency Retention Basin, the 1998 confirmatory survey identified a high Cs-137 concentration of 200 pCi/g while the 1985 high concentration of Cs-137 was 90 pCi/g. These findings are not expected to impact the degree of remediation required at these areas.

The gamma characterization information from the 1998 survey shows that the dominant gamma sources are Cs-137 and Co-60. Other gamma-emitting nuclides are only small contributors (less than 1 percent). With the exception of a single sample from canal F, gamma activity is dominated by Cs-137 at all PBRF areas (e.g., environmental contamination, sumps, floors in the Reactor Building). In canal F, the activity is dominated by Co-60.

4.2.9.2 *Major Facilities at the PBRF*

This section summarizes radiological characterization information for the major facilities at the PBRF.

Reactor Building (Building 1111)

The majority of the radioactivity at the Reactor Building is contained inside the reactor tank. The biological shield and several piping systems are also radioactively contaminated. Radioactivity was detected on the surfaces of the quadrants, canals, and drains. The following paragraphs summarize characterization data for the parts of the Reactor Building.

Reactor Tank and Internal Components

The reactor tank has the highest radionuclide inventory of all the areas at the PBRF. Radionuclide inventory estimates of the reactor tank and its internal components were presented in the 1980 environmental report (Ref. #5). To calculate the radionuclide inventory of the reactor tank, separate calculations were performed for each of the major components of the core box and beryllium reflector. Large pieces, such as through tubes, thermal shields, and the reactor tank, were analyzed as several segments. The calculations were built on estimates of integrated neutron exposure, activation cross section for the nuclides of interest in each component, the radioisotope half-life, and the decay time. Table 4.2.9.2-1 identifies the isotope of interest (first column), the June 30, 1978, inventory estimates (second column), and the 1978 inventories decayed to December 31, 2003 (third column). (Year 2003 was assumed because this is a time during which decontamination of the PBRF and waste removal is currently expected to occur.) As shown in Table 4.2.9.2-1, H-3 dominates the inventory.

TABLE 4.2.9.2-1. —*Estimated Inventory in the Reactor Tank and Internal Components*

Nuclide	Inventory (curies) as of 6/30/1978[a]	Inventory (curies) as of 12/31/2003[b]
H-3	156,800	37,266
Co-60	2,640	92
Fe-55	7,340	10.5
Ni-63	45	37
Ni-59	0.5	0.5
Zn-65	115	0.0
Al-26	1.4	1.4
Cd-113m	0.8	0.2
Total	**166,943**	**37,408**

a. From Ref. #5.
b. Calculated by decaying the 1978 inventory estimates to the year 2003.

Reactor Primary Cooling Water System and Primary Cooling Shutdown System

Two corrosion film samples from valves in the primary cooling water system were analyzed in 1985. The two samples showed similar levels of activity (256 and 375 dpm/100 cm^2). A gamma pulse height analysis conducted on the sample with higher activity identified the specific nuclides Co-60, Eu-152, Eu-154, and Eu-155. No fission products, such as Cs-137, were identified. Cobalt-60 had the highest activity of the gamma-emitting radionuclides. The lack of cesium is consistent with the historical information, indicating that there was no fuel leakage. The presence of europium is suspected to be from irradiated gadolinium that was accidentally injected by a safety system (Ref. #10). Except for special equipment (e.g., strainers and some valves), 1985 exposure rates from piping and equipment in this area were less than 30 mR/hr.

Reactor Biological Shield

The biological shield surrounding the reactor tank was activated by neutrons that entered the concrete and interacted with elements. Three core samples were taken from the biological shield in 1985 and analyzed for gross alpha, gross beta, and gamma emitters. The samples were analyzed for europium, but only Co-60 was detected. The average Co-60 concentration in the biological shield within 25 cm (10 in.) of the reactor tank was 17.5 pCi/g. A sample of the reinforcing steel in the concrete was also analyzed for gross alpha, gross beta, and gamma emitting nuclides. Cobalt-60 was detected at a concentration of 325 pCi/g in the reinforcing steel.

Reactor Quadrants and Canals, and Their Pump-out and Recirculation Systems

The 1985 characterization data for the quadrants, canals, and their pump-out recirculation systems included alpha- and beta-gamma radiation measurements of the building wells, direct radiation readings, and collected crud samples. The characterization showed:

- Reliable direct radiation measurements from the canals and quadrants were difficult to obtain because of the radiation field from the reactor tank and biological shield.
- The average concentration of loose alpha contamination, loose beta-gamma contamination, and direct radiation readings in the canals was approximately 2 dpm/100 cm^2, 1000 dpm/100 cm^2, and 0.1 mR/hr, respectively.
- Overall, the pump-out and recirculation system were contaminated internally, but they have little or no external contamination. External dose rates from piping and valves ranged from 0.01 to 0.6 mrem/hr. Drain crud samples contained 0.1 to 1 pCi/g of gross alpha activity and up to 20,000 pCi/g of gross beta activity. Cobalt-60 was the dominant gamma-emitting radionuclide.
- Direct radiation measurements in the canals ranged from 0.001 to 0.3 mR/hr.
- Deep underground soil samples were collected, and the analytical results verified that the canals (G and K) did not leak contaminated water into the ground.

As part of the 1998 confirmatory survey, a 10 cm (4-in.) diameter concrete core sample approximately 8 cm (3 in.) deep was taken from canal F, located outside the containment that connects to both the mock-up reactor and the canals going into the Hot Laboratory. Cs-137 and Co-60 were detected at concentrations of 2.7 pCi/g and 156 pCi/g, respectively.

Reactor Building Rooms

The Reactor Building rooms were surveyed in both 1985 and 1998. Loose and fixed contamination and direct radiation measurements both inside and outside the containment vessel in 1985 showed:

- Inside the containment vessel, loose alpha contamination levels ranged from 0 to 5 dpm/100 cm^2, loose beta-gamma contamination levels ranged from 0 to almost 200 dpm/100 cm^2, and direct radiation readings ranged from 0.006 to a maximum of 500 mR/hr in the sub-pile room. The average direct radiation reading in the other areas ranged from 0.01 to 0.045 mR/hr.
- Outside the containment vessel, loose alpha contamination levels ranged from 0 to 5 dpm/100 cm^2, loose beta-gamma contamination levels ranged from 0 to almost 350 dpm/100 cm^2, and direct radiation readings ranged from 0.005 to 0.230 mR/hr.

The Reactor Building rooms outside the containment vessel were also surveyed during the 1998 confirmatory survey. A total of 105 direct beta measurements and smears were taken along with a single concrete core sample at the -4.6-m (-15-ft) elevation where a hot spot was identified at the -15 ft level near the east wall (location RB056). One of the 105 beta measurements had a count rate of about 43,000 dpm/100 cm^2. Another measurement had a count rate of about 7000 dpm/100

cm^2. The remaining 103 beta measurements had count rates less than 2000 dpm/100 cm^2, and the average rate was about 100 dpm/100 cm^2.

A 10 cm (4-in.) diameter concrete core sample approximately 8 cm (3 in.) deep was taken at the hot spot (43,000 dpm/100 cm^2). Cobalt-60 and Cs-137 were detected at concentrations of 0.1 pCi/g and 0.2 pCi/g, respectively.

Hot Drains, Sumps, Pumps, and Valves

The 1985 characterization data for the hot drain system included alpha and beta-gamma radiation measurements, direct radiation readings, and collected crud samples. Direct radiation readings from the hot drain system sumps ranged from 0.007 to 2 mR/hr. Ten of the 12 sumps had average readings of 1.2 mR/hr. Crud samples from the hot sumps had elevated alpha and gamma radiation readings, with alpha activity levels ranging from 15 to 9500 pCi/g, and gamma activity levels ranging from 580 to 130,000 pCi/g. The dominant gamma-emitting radionuclides were Co-60 and Cs-137.

Hot Laboratory (Building 1112)

Most of the radioactive contamination in the Hot Laboratory is from stored waste in the Hot Dry Storage Area. Contamination has also been identified in the hot cells and rooms surfaces.

Hot Dry Storage Area

The waste in the Hot Dry Storage Area of the Hot Laboratory has the second highest estimated radionuclide inventory of all the contaminated areas at the PBRF. This waste consists of radioactively contaminated items similar to that in the reactor tank (e.g., beryllium pieces and control rod sections). Estimates of radionuclide inventories in the Hot Dry Storage Area were presented in the 1981 environmental report (Ref. #5 and also in Ref. #10). The method for estimating the inventories is discussed in Appendix A of the 1980 environmental report and involves separate calculations for each of the major components. The calculations were built on estimates of integrated neutron exposure, activation cross section for the nuclides in the various components, the half-life of the active isotopes, and the decay time. These inventory estimates, as of June 30, 1978, are presented in the second column of Table 4.2.9.2-2. The 1978 inventories were decayed to December 31, 2003, a time during which decontamination of the PBRF and waste removal is currently expected to occur (third column). As shown in Table 4.2.9.2-2, H-3 dominates the inventory.

During the 1985 characterization, TLDs were lowered into the Hot Dry Storage Area to obtain dose rate measurements. No smear samples, which indicate surface contamination levels, were taken inside the Hot Dry Storage Area.

TABLE 4.2.9.2-2. —*Estimated Radionuclide Inventory of the Waste in the Hot Dry Storage Area*

Nuclide[a]	Inventory (curies) as of 6/30/1978[b]	Inventory (curies) as of 12/31/2003[c]
H-3	34,600	8,223
Co-60	16,100	559
Fe-55	14,600	16
Zn-65	1	0.0
Total	**65,301**	**8,798**

a. Other nuclides were calculated to be less than 1 percent of the total.
b. From Ref. #5.
c. Calculated by decaying the 1978 inventory estimates to the year 2003.

Hot Cells

The seven hot cells in the Hot Laboratory were surveyed in 1985 using instrument scans and wipe samples. Loose alpha contamination in the cells ranged from 0 to 370 dpm/100 cm^2, and loose beta-gamma contamination ranged from 200 to 173,000 dpm/100 cm^2. Direct radiation ranged from 1 to 450 mR/hr. Isotopic analyses of wipe samples with the highest contamination levels indicated that Co-60 and Cs-137 dominate the measured activity.

Rooms

The rooms in the Hot Laboratory include the decontamination room, repair shop, storage room, mezzanine, cold work area, hot work area, and hot handling area. The floors, walls, and ceilings of the rooms were surveyed in 1985 using instrument scans and wipe samples. The 1985 characterization data show that contamination levels in the Hot Laboratory rooms, exclusive of the decontamination room, were similar to those in the Reactor Building rooms outside of the containment vessel. For areas other than the decontamination room, the loose alpha contamination ranged from 0 to 8 dpm/100 cm^2 and loose beta-gamma contamination ranged from 0 to 18,852 dpm/100 cm^2. Direct radiation levels in these same areas ranged from 0.003 to 1 mR/hr. The decontamination room had loose alpha contamination as high as 208 dpm/100 cm^2, loose beta-gamma contamination as high as 337,000 dpm/100 cm^2, and dose rates as high as 8 R/hr.

4.2.9.3 *Support Facilities and Other Areas at the PBRF*

Radiological characterization information for the contaminated support facilities at the PBRF are briefly discussed in the following paragraphs. The support facilities are smaller and have lower levels of contamination than the major facilities described in Section 4.2.9.2. The contamination generally is in readily removable equipment or in areas that are more simply decontaminated. The structures themselves have limited contamination. A summary of characterization information for the contaminated support facilities is presented in Table 4.2.9.3-1. Also discussed in this section are areas of contaminated pavement.

The highest contamination levels found in the support facilities during the 1985 survey were in the hot pipe tunnels (shown in Figure 1.1-2). The piping in the tunnel, which was used to handle radioactive liquid and gasses, contains radioactive contamination, and the tunnel floor is radioactively contaminated in one area.

The next highest contamination levels were in an evaporator in the basement of the Waste Handling Building (#1133). Other equipment and piping in this building contain radioactive contamination, and surface contamination has been identified throughout the building. In the Fan House (#1132), equipment (e.g., ducts and piping) contains measurable radioactive contamination, and contamination has been identified throughout the basement floor. In the Reactor Office and Laboratory Building (#1141), radioactive contamination has been found on laboratory hoods, in piping, and on the floors of some of the radiochemistry laboratories. In the Primary Pump House (#1134), equipment and piping, as well as pits and sumps, contain radioactive contamination.

At the Hot Retention Area (#1155), the storage tanks and associated piping and equipment are radioactively contaminated, and low levels of contamination (i.e., less than the levels in Regulatory Guide 1.86 [USAEC 1974], according to Ref. #10) have been identified in the concrete vault. At the Cold Retention Basins (#1154), the basin liners, concrete structures, and the silt deposits on the liners are radioactively contaminated. Underground soil samples collected in 1985 verified that the Hot Retention Area and Cold Retention Basins did not leak contaminated water into the ground.

The areas examined in the 1998 survey generally confirmed the results. For the Fan House, Waste Handling Building, and Reactor Office and Laboratory Building, the 1998 results are consistent with the 1985 results. In general, the more extensive 1985 survey and the 1998 verification survey showed that there was only localized contamination in the support structures.

Areas of Contaminated Pavement

Two areas of known low-level waste spills have been identified: one near the Waste Handling Building (#1133) concrete pad and one in the vicinity of the Primary Pump House (#1134) resin pits (see Figure 1.1-2). The 1985 characterization effort involved collecting deep and shallow cores near the concrete pad at the Waste Handling Building. Samples from the cores showed radiological contamination to a depth of 1.8 m (6 ft). At the same location, gross beta activity measurements were 1500 pCi/g at a depth of 0.3 m (1 ft) and 100 pCi/g at a depth of 1.8 m (6 ft). Gross alpha activity measurements at the same depths were 90 and 7 pCi/g, respectively. No radiological concentration was reported for the second spill area in the vicinity of the Primary Pump House (#1134) resin pits. The 1998 survey confirmed the presence of contamination near the Waste Handling Building, but no contamination was detected at the previously identified spill area near the Primary Pump House.

During the 1998 survey, an additional contaminated location was identified on the pavement near the entrance to the Reactor Building, where total beta activity up to 42,000 dpm/100 cm^2 was measured.

Table 4.2.9.3-1. ***Summary of Survey Results for Support Facilities at the PBRF***

Building/ Structure	Summary of 1985 Characterization Survey Results	1998 Confirmatory Survey	
		No. of Survey Measurements	Results
Reactor Office and Laboratory Building (1141)	• Loose alpha contamination ranging from 0 to 4 dpm/100 cm^2 • Loose gamma-beta contamination ranging from 0 to 137 dpm/100 cm^2 • Average direct radiation less than 0.02 mR/hr	• 120 direct beta measurements • 120 smears	• Two measurements were about 50,000 dpm/100 cm^2 • Three measurements were between 5000 and 10,000 dpm/100 cm^2 • All others were less than 2000 dpm/100 cm^2
Primary Pump House (1134)	• Loose alpha contamination ranging from 0 to 2 dpm/100 cm^2 • Loose gamma-beta contamination ranging from 0 to 29 dpm/100 cm^2 • Direct radiation about 0.01 mR/hr	None	None
Fan House (1132)	• Loose alpha contamination ranging from 0 to 2 dpm/100 cm^2 • Loose gamma-beta contamination ranging from 0 to 102 dpm/100 cm^2 • Direct radiation less than 1 mR/hr	• 60 direct beta measurements • 60 smears	• One measurement was about 7000 dpm/100 cm^2 • All others were less than 2500 dpm/100 cm^2
Waste Handling Building (1133)	• Loose alpha contamination ranging from 0 to 5 dpm/100 cm^2 • Loose gamma-beta contamination ranging from 0 to 11797 dpm/100 cm^2 (the highest value is in the basement; the next highest value is 2000 dpm/100 cm^2) • Direct radiation ranges from 0.02 to than 3 mR/hr	• 60 direct beta measurements • 60 smears	• One measurement was about 7000 dpm/100 cm^2 • Most others were less than 2500 dpm/100 cm^2
Hot Retention Area (1155)	• Tanks are contaminated; concrete vault contamination was less than the levels in Regulatory Guide 1.86 (USAEC 1974) • Direct radiation ranged from 0.044 to 2.8 mR/hr	None	None
Cold Retention Basins (1154)	• Alpha contamination ranged from 0 to 3 dpm/100 cm^2 • Beta contamination ranged from 25 to 1061 dpm/100 cm^2 • Direct radiation less than 0.1 mR/hr	• 8 direct beta measurements • 8 smears	Wipe samples range from 1000 to 5000 dpm/100 cm^2
Hot pipe tunnel	• Activity primarily in the 4-in. polyethylene piping. Contact dose rates range from 6 to 2200 mR/hr • Loose alpha contamination ranged from 0 to 17 dpm/100 cm^2 • Loose beta-gamma contamination ranged from 0 to 47,363 dpm/100 cm^2 with a hot spot from line leak • Direct radiation ranged from 2 to 85 mR/hr	None	None

4.2.9.4 *Facilities Expected to be Clean*

Based on the 1985 and 1998 characterization information, several support facilities within the PBRF fence were determined to be uncontaminated. These facilities are the:

- Service Equipment Building (#1131)
- Gas Services Building (#1135)
- Compressor Building (#1136)
- Substation (#1161)
- Security Building (#1191).

Based on historical knowledge, at the time of the 1985 characterization survey, the following facilities were considered to be uncontaminated and were not surveyed. This assessment was not revisited as part of the 1998 confirmatory survey:

- Cold pipe tunnel
- Water tower (#1151)
- Sludge basins (#1153)
- Precipitator (#1157)
- Cryogenic and Gas Supply Farm and Building (#1195 & #9837)
- Gas Storage Structure (#1196).

These facilities will be surveyed as part of the final status survey of the Decommissioning Project.

4.2.10 Hazardous Waste Management

No hazardous waste is currently generated at the PBRF because it is not utilized. Hazardous waste management practices when the facility was active were discussed in Section 3.2.

4.2.11 Pollution Prevention and Recycling

No pollution prevention and recycling activities occur at the PBRF because it is non-operational and mothballed. There are no NASA personnel working at the PBRF on an 8-hour per day basis. Hence, no materials are used that would necessitate pollution prevention or recycling actions.

4.2.12 Pesticides/Herbicides

During the site visit, NASA personnel reported that pesticides and herbicides are used at the PBRF on an "as needed" basis to clear vegetation from the foundations of buildings and at the fence line. An outside contractor does all pesticide and herbicide applications. No pesticides or herbicides are stored at the PBRF.

Pesticide/herbicide use when the facility was active was discussed in Section 3.2.

4.2.13 Storage Tanks and Pipelines

Storage tanks and pipelines at the PBRF can be divided into three groups: those used to manage low-level contaminated water, and those associated with water treatment or fuel storage.

Low-level Contaminated Water

The Hot Retention Area (#1155) contains eight 227,100 liter (60,000 gallon) underground storage tanks within a concrete vault that were used to contain radioactively contaminated water from the hot drain system, and the canals and quadrants of the reactor. The Cold Retention Basins (#1154) each held approximately 1.9 million liters (500,000 gallons) of water and were also used to store water from the quadrants and canals. The existing radiological contamination at both of these areas was discussed in Section 4.2.9.

Water Treatment

The Water Tower (#1151) held both raw and treated water. It is not expected to be radiologically contaminated. Similarly, the Precipitator (#1157) was used as part of the water treatment process and is expected to be radiologically clean.

Several caustic and acid above ground storage tanks have been removed (removal dates unknown). Each was about 760 liters [200 gallons]. One pair (one of each) were associated with the water treatment system and were located just west of the Precipitator. Another pair were located just west of the Fan House (#1132). Similarly, an above ground storage tank containing acid was present adjacent to the Cooling Tower (#1152), but it too has been removed.

Fuel Storage Tanks

There is one above ground fuel storage tank currently at the PBRF. It holds approximately 1,325 – 1,500 liters (350 – 400 gallons) and was used to store diesel fuel for the boilers. It is located just off the northeast corner of the Service Equipment Building (#1131). During the site visit it was noted that the tank has a plate on the side dated 1942 and that stained soil was present beneath the east end of the tank. NASA personnel interviewed reported that this tank had a significant overflow during filling in about 1975. Diesel fuel flowed to the catch basin located approximately 18 meters (60 feet) north of the tank and a substantial quantity reached the Water Effluent Monitoring Station. NASA personnel constructed a dike to prevent the fuel from entering Pentolite Ditch. When enough fuel was present, it was ignited. NASA personnel were unable to estimate the quantity of fuel released.

Three underground storage tanks were located just off the southwestern-most corner of the Services Equipment Building (#1131). Two of these were diesel fuel tanks; they were removed in 1989 according to state regulations. The third tank was used to store waste solvents and oils. It was also removed in 1989. However, residual contamination remains in site soils and groundwater. Corrective actions under the *Resource Conservation and Recovery Act* are necessary to address dissolved phase VOCs in groundwater in the immediate vicinity of this former tank. A remediation system, consisting of a groundwater recovery and treatment system, has been designed to treat the contaminated groundwater. A recovery well will be installed near existing monitoring well EB-RA-05 (see Figure 4.2.2.1-1). The current plan is to house the groundwater treatment system inside Building 1131 (Ref. #42).

4.2.14 Surface Impoundments

Surface impoundments present at the PBRF are the Emergency Retention Basin in the southeast part of the facility, the Sludge Basins (#1153) in the northeast corner of the fenced area, and the Drying Basins in the northern part of the site, outside the fence. The Emergency Retention Basin is known to be contaminated by radionuclides, as discussed below. Neither the Sludge Basins nor the Drying Basins are thought to contain radiation above background levels because they were part of the raw water treatment system and therefore should not have been in contact with radioactive substances.

Emergency Retention Basin

As discussed in Section 3.2, during operations the Emergency Retention Basin was used for emergency storage of radioactively contaminated water, and the stored water could evaporate, percolate into the soil, decay off and be discharged, or be diluted and discharged. Therefore, the soil in the basin was contaminated with radionuclides. This area was characterized during both the 1985 and 1998 studies; the contaminants are Cs-134, Cs-137, and Sr-90. Surface soil in the Emergency Retention Basin (i.e., from 0 to 15 cm [0 to 6 in] below the surface) and soil from 15 to 30 cm (6 to 12 in.) below the surface in specific areas is radioactively contaminated.
The 1985 characterization of the Emergency Retention Basin included collecting shallow (0 to 3.0-m [0 to 10-ft]) cores, near-surface (5 to 15-cm [2 to 6-in.]) soil samples, and surface (0 to 5-cm [0 to 2-in.]) soil samples. The shallow cores were analyzed for gross alpha and gross beta activity and the results indicated that the residual activity was confined to the upper 15 cm (6 in.) of soil. Near-surface soil samples collected from the Emergency Retention Basin indicated that gross beta activity averaged 78 pCi/g. Surface soil samples collected at locations where the near-surface samples showed the highest activity levels were also analyzed for gross beta activity. Radionuclide concentrations in the surface soil samples were 10 to 20 times greater than that in the near-surface samples.

The near-surface samples having the highest activity also were analyzed to determine the isotopic distribution. The average Co-60, Cs-137, and Sr-90 concentrations in the near surface samples were 22, 32, and 2.4 pCi/g, respectively.

During the 1998 confirmatory survey, a gamma scan was conducted (about 1.3 cm [0.5 in.] from the surface) and five soil samples were collected. The gamma scan showed peak exposure rates of about 50 μR/hr, with average exposure rates ranging from 20 to 30 μR/hr. These exposure rates are generally similar, but they are slightly less than those reported in the 1985 survey. The soil samples taken in 1985 were from the southern portion of the Emergency Retention Basin (the most contaminated area in the 1985 survey). The decay-adjusted 1985 concentrations and the 1998 concentrations are within a factor of 3 of each other. The differences could be due to the different sample locations and the contamination not being homogenous. The lower concentrations at the 0 to 5-cm (0 to 2-in.) depth and the higher concentrations at the 5 to 15-cm (2 to 6-in.) depth may indicate downward contaminant migration.

Sludge Basins and Drying Basins

As mentioned above, the Sludge Basins and Drying Basins were part of the raw water treatment system. Raw water was obtained from Lake Erie and treated onsite by adding alum, lime, chlorine, and an acid or caustic to adjust pH as necessary. During the records review conducted as part of this EBS, a process flow diagram was found that showed “3 chemical feed lines and chlorine line.” However, no records were found that identified exactly the “3 chemicals.” Although chlorine was used, it is possible that an algaecide or similar chemical was also used to control microorganism growth in the process water.

Interviews with personnel that worked at the PBRF when it was active found that periodically the water and/or sludge from the Sludge Basins was sampled and analyzed at the onsite laboratory in the Services Equipment Building (#1131). Although the exact analytical parameters analyzed for are unknown, it was stated that if the results were acceptable, the water and/or sludge from the Sludge Basins would then be pumped to the Drying Basins. Engineering drawings of the facility show a 3-inch sludge discharge line connecting the Sludge Basins and the Drying Basins.

During the site visit, it was noted that the Sludge Basins are currently holding water and that the Drying Basins are overgrown with vegetation and not distinguishable from the surrounding natural landscape.

4.2.15 Radon

A 1987 study of radiological contamination at the PBRF discovered elevated concentrations of radon- 222 (a radioactive daughter product from the decay of radium-226) (Ref. #9). Radon 222 is a naturally occurring isotope that persists as a radioactive gas with a half-life of 3.8 days. The study found elevated concentrations of radon present throughout the containment vessel in building #1111, with high concentrations particularly noticeable at the lower elevations. The report noted that since the containment vessel is sealed off from the subterranean structures by means of the steel shell and massive concrete, the source of the radium is not likely to be from the earth itself. Instead, it was determined that the radon gas must be emanating from the massive concrete structures of the containment vessel. Large amounts of local stone (gray shale) are present as aggregate in this concrete. Tests of the gray shale, referred to in geological circles as Huron or Mentor shale, which underlie the entire Plum Brook Station, have shown that it contains naturally high levels of radium-226, which is a decay product of the natural uranium present in these formations (Ref. #9).

During operations, normal air turnover in the facility purged the radon-222 from the facility; however, the ventilation system has not operated since the shutdown in 1973. As a result, radon gas has and will continue to accumulate in the containment vessel. For radon concentrations in the range of 4 to 20 pCi/1, the EPA requires temporary and/or permanent remedial action to be taken to reduce levels below 4 pCi/l (Ref. #9).

During the site visit, continuous radon monitoring equipment was observed within the containment vessel. When the radon levels approach 4 pCi/1, NASA personnel take measures to instigate the normal turnover of air to vent the area. This is done on a regular basis, approximately once per month.

4.2.16 Onsite and Offsite Transportation of Solid Waste, Hazardous Waste, and Radioactive Waste

There is no onsite or offsite transportation of solid or hazardous waste from the PBRF. The PBRF was shut down in 1973 and has been mothballed since then. No NASA personnel work at the PBRF on an 8-hour per day basis, but only check on the facility daily. Therefore, there are no personnel on site to generate solid or hazardous waste that would need to be transported on (within) or off the site.

There is no onsite transportation of radioactive waste on the PBRF, but there is offsite transportation. As stated in Section 4.2.8, Waste Management, there is a small amount of low-level radioactive waste consisting of disposable personnel protective equipment generated by NASA personnel during routine maintenance and environmental sampling activities. This waste is stored in 55-gallon drums that hold approximately 7 ½ cubic feet of material per drum. During the site visit, 11 55-gallon drums of this waste was stored onsite in the Waste Handling Building (#1133).

NASA personnel stated that they periodically call a licensed transporter to transport the drums to a licensed Class A low-level radioactive waste facility for disposal. Transportation of waste when the facility was active was discussed in Section 3.2.

4.2.17 Traffic and Parking

Since there is no regular activity at the PBRF, traffic and parking is currently not an issue. During operation, PBRF employees used a large parking lot approximately 500 feet southwest of the Reactor Building (#1111). During the site visit, the parking surface was observed have multiple fractures with vegetation growing through fractures.

4.2.18 Natural and Cultural Resources

The information in this section has been primarily summarized from References #19 and #53.

4.2.18.1 *Biological Resources*

Plum Brook Station is part of a regional ecosystem encompassing Sandusky, parts of Lake Erie, and several Lake Erie islands. The station contains significant areas of grassland, bushland, and woodlands. A biological survey conducted in 1994 determined that no significant plant communities were located at Plum Brook Station (Ref. #19). A total of 327 vascular plant species were collected or observed during the 1994 survey, and, of these, 251 species are indigenous to the area. The plant species number was considered low due to a history of disturbance and the predation of deer. A number of wildflowers prevalent throughout other areas in Erie County are absent from the PBS because of excessive browsing. Areas of greatest plant diversity are in the central and southern portion of Plum Brook Station and not near PBRF (Ref. #19).

The 1994 Survey found 116 bird species during the summer birding season on the PBS (Ref. #19). Of these, 92 species were either confirmed or likely nesters. Five species were considered to be late migrants and nine species visitors only. Common birds at the PBS include the American robin, the red-winged blackbird, the European starling, the song sparrow, and the common grackle. The amphibian and reptile survey found 2 species of salamanders, 7 species of frogs and toads, 6 species of snakes and 4 species of turtles. None of these amphibian or reptile species were listed as Federal or state endangered or threatened species (Ref. #19). Several streams, ponds and artificial water bodies exist on the PBS. The 1994 Survey found 14 species of fish, which are common State-wide and tolerant of water quality and habitat degradation, except for the brook stickleback (Ref. #19). Forty-one species of butterfly and 385 species of moth were recorded in the 1994 Survey. Mammals at Plum Brook Station include white tailed deer, raccoons, woodchucks, moles, and coyotes. Large populations of deer and coyotes are reported to be on the PBS. The 1994 Survey suggests that while coyotes feed mainly on small mammals and birds, the large deer population also provides a food source for the coyote (Ref. #19).

4.2.18.2 *Wetlands and Floodplains*

Portions of Plum Brook Station lie within the 100-year and 500-year floodplains. The PBRF is located neither in the 100-year or 500-year floodplain, nor have wetlands been delineated in the immediate vicinity of the PBRF, based on review of floodplain and national wetlands inventory maps, respectively (Ref. #53). Most of the identified wetlands are small, isolated palustrine emergent, scrub shrub, or forested. Past PBRF site development including the construction of drainage ditches to prevent the accumulation of standing water have reduced the potential for wetland formation (Ref. #53).

4.2.18.3 *Endangered and Threatened Species*

The biological survey conducted in 1994 noted that a number of vascular plants species that were once common to the area had become rare on the PBS, surviving only as individual populations rather than in intact communities. This pattern reflects the fragmented nature of the area and its history of disturbance (Ref. #19). Table 4.2.18.3-1 lists those species ranked by the Division of

Natural Areas and Preserves as Ohio Rarities as endangered (E), threatened (T) and potentially threatened (P).

TABLE 4.2.18.3-1.—*Endangered, Threatened and Potentially Threatened Vascular Plant Species at Plum Brook Station*

Type	Species	Common Name
Endangered	*Carex cephaloidea*	Thin-leaf sedge
	Hypericum gymnanthum	Least St. John's-wort
Threatened	*Arenaria laterifolia*	Grove sandwort
	Carex conoidea	Field sedge
	Helianthus mollis	Ashy sunflower
Potentially Treatened	*Baptisia lactea*	Prairie false indigo
	Carex alata	Broad-winged sedge
	Gratiola virginiana	Round-fruited hedge-hyssop
	Hypericum majus	Tall St. John's-wort
	Rhexia virginiana	Virginia meadow-beauty
	Scleria triglomerata	Tall nut-rush
	Viola lanceolata	Lance-leaved violet

One Federally-listed species, the bald eagle (*Haliaeetus leucocephalus*), was observed during the 1994 Survey near one of the reservoirs. While this species did not nest on the PBS at the time, it is likely that it is a sporadic visitor to the area (Ref. #19). A 1991 report stated that approximately four breeding pairs of the bald eagle occur within 5 to 10 miles of Plum Brook Station (Ref. #12). The Indiana bat (*Myotis sodalis*) is also listed as a Federal and state-endangered species in Erie County, where the Station is located. The 1991 report notes that no survey has been conducted to identify habitats of the Indiana bat in the Plum Brook area (Ref. #12); it is not known if such a survey has been conducted in the meantime.

Several state-listed rare and endangered bird species were found on the PBS during the 1994 survey: Cooper's hawk, upland sandpiper, alder flycatcher, least flycatcher, sedge wren, marsh wren, Brewster's warbler, black-throated green warbler and Henslow's sparrow (Ref. #19).

Three species of special concern were identified at Plum Brook Station: Blanding's turtle, eastern fox snake and the smooth green snake. None of these protected or special status species were identified at the PBRF (Ref. #19).

Three species of state-endangered moth (*Papaipema silphii*, *Spartiniphaga inops*, and *Hypocoena enervata*) have been found in nature preserves within 5 miles of the Plum Brook Station and their associated habitats (wetlands and Prairie Dock) exist at Plum Brook Station (Ref. #12).

During the site visit for this EBSR, it was noted that the only vegetation within the fenced PBRF area is grass.

4.2.18.4 *Historic, Archaeological, and Cultural Resources*

The Spacecraft Propulsion Research Facility (B-2 Facility) is the only building at Plum Brook Station that has been designated a National Historic Landmark. Native American archaeological sites have been identified in the Plum Brook Station area, but only outside of the Plum Brook Station fence line (Ref. #53).

Currently, no facilities at the PBRF have been identified as historic resources, and no archaeological or cultural resources have been identified at the facility. Due to the extensive grading and other earth-disturbing activities that occurred during construction of the PBRF, it is unlikely that any intact subsurface archaeological or cultural resources would be present at the site. However, as part of the pre-decommissioning activities, a letter initiating the Section 106 Consultation Process regarding the potential historical status of the PBRF has been sent to the State Historic Preservation Officer (SHPO) (Ref. #53). The SHPO has responded with a “no interest” determination.

4.3 FORMER PENTOLITE AREA WASTE LAGOONS

As discussed in Section 3.1, Past Uses, the area that is now the PBRF was originally part of the Plum Brook Ordnance Works known as the Pentolite Area. Pentolite, a high explosive, was manufactured here. The Pentolite Area Waste Lagoons were located in what is now the southwestern portion of the PBRF.

In 1999, a Limited Site Investigation of the Pentolite Area Waste Lagoons was conducted as part of the DERP/FUDS program. As part of this investigation, five soil borings were installed in the area of the former waste lagoons. No groundwater samples were collected. The soil samples were analyzed for VOCs, Target Analyte List Metals, and explosives. No explosives were detected in any of the samples, nor were any RBCs exceeded for any of the other analytes. The report concluded that contamination was not revealed by the field activities and therefore it appears that the operation and decommissioning activities associated with the waste lagoons did not release significant contaminants into the environment.

4.4 PRE-DECOMMISSIONING ENVIRONMENTAL CHARACTERIZATION

In August 2000, surface and subsurface (1-5 feet) soil samples were collected at various locations around the PBRF in accordance with the *Decommissioning Pre-Design Investigation Plan* (Ref. #49). Several areas of low-level VOC, SVOC, and PCB soil contamination were identified. However, except for 1 sample that contained an estimated concentration of an SVOC above the RBC, the concentrations detected were well below available RBCs (Ref. #50).

4.5 COMMUNITY RELATIONS

As part of the decommissioning project of the PBRF, NASA has created a Community Relations Plan (CRP) to lay out the mechanisms for informing and involving the public in activities and decisions related to the project. The plan meets the requirements for Public Participation outlined by the Nuclear Regulatory Commission’s (NRC) Final Rule of License Termination, FR

Vol. 62, No. 139, 7/21/97. The goals and methods of community outreach are broad. The methods of community outreach include: news releases; media advisories; public services announcements; direct mailings; exhibits; fact sheets; web site; community/public information sessions; open house/tour of the Plum Brook Station; videotape presentations; briefings/presentations to local officials; public meetings; community information bank/center; newsletter, and so on. The CRP indicates that many of these activities are to occur when the decommissioning of the PBRF begins.

A number of community outreach activities have occurred and are on-going. These include the posting of a web site (http://www.lerc.nasa.gov/WWW/pbrf/), the establishment a Community Information Bank (CIB) at the Firelands College Library in Huron, Ohio, the institution of. Community Workgroup, and regular meetings between the NASA Decommissioning Project Manager and local township and county officials. The CIB is a repository of information on the decommissioning of the PRBF and is continually updated and available to the public upon request. The Community Workgroup consists of fourteen men and women of Erie and Huron counties that participate in a variety of community activities and professions, including the area's educational, environmental and minority communities. The Workgroup meets quarterly, and the meetings are open to the public with public service announcements aired on local radio stations in advance of the meetings. The Workgroup meeting minutes are available on the web site. The Workgroup's most recent meeting occurred October 17, 2000. Informal meetings between various local township and county officials and the NASA Decommissioning Project Manager and a NASA GRC Public Affairs Specialist to discuss NASA's plans for decommissioning have occurred since July 1999.

An upcoming community involvement activity is the 30-day public review of the Draft EA NASA is preparing on the PBRF Decommissioning Project. When the Draft EA is completed, an availability announcement will be published in the local newspaper and media and the document will be made available for public review and comment for 30 days. Copies of the document will be available in the CIB at Firelands College. In addition, a summary presentation will be given to the Community Work Group during the 30-day comment period.

Previous community outreach activities that included the decommissioning of the PBRF include an Open House and Tour of the Plum Brook Station on October 30, 1999, and a community information session on the decommissioning of the PBRF on November 3, 1999. The Open House and Tour was of the entire Station, with a drive-by of the PBRF site and question and answer session on future decommissioning plans for the site. The NASA GRC and Plum Brook Station have sponsored a number of other educational and outreach activities in the community on other work done at the Station contributing to space exploration.

4.6 ENVIRONMENTAL JUSTICE

From 1990 Census data, the *Environment Justice Implementation Plan for NASA Lewis Research Center* identified a total of 30,500 persons, of whom approximately 4,200 are black and 450 are Hispanic (15.25% of the population) that live within a 5-mile radius of the PBS, including the entire City of Sandusky.

For this EBSR, a search of 1990 Census data was conducted to determine the number of people living within a one-mile radius of the PBRF site. As of 1990, a total of 761 persons lived within 1 mile of the PBRF and 0 persons lived within 0.5 mile of the facility. To determine the minority population within the one-mile radius, Census Block Group data were reviewed. Figure 4.6-1 shows the four Census Block Groups that intersect the one-mile radius of the PBRF and their minority and below poverty population percentages.

All of the Block Groups (BGs) except 6004 extend beyond the boundaries of the figure. BG 5002 and 6001 extend northward, while BG 6003 extends to the west. Only 1.1% of BG 5002 and 20.1% of BG 6001 lie within the one-mile radius. While the entire BG 6004 is within the boundaries of the figure, only 35.2% of it is within the one-mile radius. BG 6003 covers the remainder of the radius.

The percentages of minority and below poverty populations listed on the figure for each BG are for the entire BG. For example, BG 5002 has 2.3% minority and a 2.7% below poverty populations, but only 1.1% of the entire BG 5002 is within the one-mile radius. Similarly, BG 6001 has 2.3% minority and 0.7% below poverty populations with only 20.1% of the entire BG within the one-mile radius. BG 6004 has 6.0% minority and 4.7% below poverty populations with 35.2% of the BG within the one-mile radius. And while BG 6003 shows 1.2% minority and 2.8% below poverty populations, these populations are located in areas not shown on the figure, as no one lives on the PBS. The 716 persons found within the one-mile radius live north of Bogart Road and east of the PBS boundary on Columbus Avenue in BGs 5002, 6001 and 6004.

The standard used to determine environmental justice impacts on minority and below poverty populations is based on county percentages. The PBRF is in Erie County. Census data from 1990 identified 76,799 persons in the Erie County, of whom 7,907, or 10.23%, compose the minority population of Erie County. The percentage of the Erie County population below poverty is 9% (Ref. 18). The data from BG 5002, 6001 and 6004 have a combined minority population percentage of is 10.6% and a combined below poverty percentage of 8.1%. Because only a portion of each BG is within the one-mile radius, it is unlikely that the entire minority and below poverty populations of each BG are found within the portion covered by the one-mile radius.

4.7 ENVIRONMENTAL CONDITION OF PROPERTY AT THE PBRF

Since this EBS was conducted in accordance with ASTM Standard 6008-96, *Standard Practice for Conducting Environmental Baseline Surveys*, the Property Categorization Scheme identified in that standard is being used. Table 4.7.1 shows the property category definitions.

Most buildings at the PBRF have some type of contamination that requires remediation and are therefore included in category 6. The categorization of the buildings and land at the PBRF is discussed below and summarized in Table 4.7-2. The environmental condition of property map is shown in Figure 4.7-1.

Category 1 Areas

The open space at the PBRF that is not placed into another category as shown on Figure 4.7-1 is classified as Category 1 property. These areas have either been sampled and shown to be free of contamination, or they are areas for which no data has been identified indicating that a release or migration of hazardous substances or petroleum products has occurred**.**

TABLE 4.7-1.—*ASTM Property Categorization*

Type No.	Environmental Condition of the Property (ECP) Area Category Definitions
1	Areas where no storage, release, or disposal of hazardous substances or petroleum products has occurred (including no migration of these substances from adjacent areas)
2	Areas where only storage of hazardous materials, hazardous substances or petroleum products has occurred (but no release, disposal, or migration from adjacent areas has occurred)
3	Areas where storage, release, disposal, and/or migration of hazardous substances or petroleum products has occurred, but at concentrations below action levels
4	Areas where storage, release, disposal, and/or migration of hazardous substances or petroleum products has occurred, and all remedial actions necessary to protect human health and the environment have been taken
5	Areas where storage, release, disposal, and/or migration of hazardous substances or petroleum products has occurred, removal and/or remedial actions have been selected and may be underway, but all required remedial actions have not yet been taken
6	Areas where storage, release, disposal, and/or migration of hazardous substances or petroleum products has occurred at concentrations above action levels, but required response actions have not yet been implemented.
7	Areas that are unevaluated or require additional evaluation

TABLE 4.7-2.—*Facility Categorization Matrix*

Building No.	Building Name	Type of Contamination Identified	EBS Category Number
1111	Reactor Building	Radiological, ACM, LBF, PCBs	**6**
1112	Reactor Hot Laboratory	Radiological, ACM, PCBs	**6**
1131	Reactor Services Equipment Building	Radiological, ACM, LBP, PCBs, Diesel Fuel	**6**
1132	Reactor Fan House	Radiological, ACM, LBP, PCBs	**6**
1133	Reactor Waste Handling Building	Radiological, LBP, PCBs	**6**
1134	Reactor Primary Pump House	Radiological, LBP	**6**
1135	Reactor Gas Services Building	N/A	**1**
1136	Reactor Compressor Building	LBP, PCBs, Oil	**6**
1141	Reactor Office and Laboratory	Radiological, PCBs	**6**
1151	Reactor Water Tower	LBP (X-Ray Fluorescence)	**6**
1152	Reactor Cooling Tower (Removed); foundation and valve posts remain	LBP (X-Ray Fluorescence)	**6**
1153	Reactor Sludge Basins	N/A	**7**
1154	Reactor Cold Retention Basins	Radiological	**6**
1155	Reactor Hot Retention Area	Radiological	**6**
1157	Reactor Precipitator	LBP (X-Ray Fluorescence)	**6**
1161	Reactor Substation	PCBs removed	**4**
1191	Reactor Security Building	N/A	**2**
1192	Reactor Water Effluent Monitoring Station	Radiological	**7**
1195 & 9837	Reactor Cryogenic and Gas Supply Farm and Building	N/A	**1**
1196	Reactor Gas Storage Structure (Removed)	N/A	**1**
N/A	Drying Basins	N/A	**7**
Open space	N/A	Various	See Figure 4.7-1

The *Reactor Gas Storage Structure (#1196)* was used strictly to store hydrogen gas and was removed when the PBRF was shutdown. The cement foundation is currently present and the area is now covered with grass. While it is near the Reactor Compressor Building that has LBP, PCBs and oil contamination, it is not likely that any of that contamination has migrated to the former Gas Storage Structure area. It is equally not likely that any radiological contamination has migrated to the structure.

The *Reactor Cryogenic and Gas Supply Farm and Building (#1195 and #9837)* were part of the same system as the Gas Storage Structure described above. The building was removed and this area is currently overgrown with vegetation. For the same reasons as discussed above for the Gas Storage Structure, this area is included in Category 1.

Category 2 Areas

The *Reactor Security Building (#1191)* was and is used strictly as the ingress/egress point to the PBRF. There is no known or suspected contamination in this building. But because monitoring equipment is stored here that contains radioactive check sources, this building is classified as an area where only storage of hazardous materials has occurred.

Category 3 Areas

The area of the former Pentolite Area Waste Lagoons, an approximately 5,850 square meter (107 m x 55 m) [63,000 square foot (350 ft x 180 ft)] area in the southwest portion of the PBRF, is classified as Category 3. This is because of its documented history of receipt and storage of nitroaromatic-contaminated wastewater and recent characterization of no identified contamination remaining in the soils.

During the latest environmental characterization effort at the PBRF, soil samples from several areas were found to contain trace levels of VOCs, SVOCs, and PCBs (all less than 100 parts per billion). Because the concentrations detected were estimated values and all but one were well below available RBCs, these areas are included in Category 3. Although the extent of these areas of apparently very minor contamination is not delineated, the trace levels found indicate that no further investigation is necessary.

Category 4 Areas

Transformers present at the *Reactor Substation (#1161)* were found to contain PCBs and were removed in the early 1980s.

Category 5 Areas

The only Category 5 area at the PBRF is the area adjacent to the southwest corner of Building 1131 where the former waste solvent UST was located. This area is being addressed under the state RCRA program. Contaminated soils have been removed and the Ohio EPA has approved the installation of a groundwater pump-and-treat system as the remedial action. This treatment system is currently in the final design stage.

Category 6 Areas

All areas discussed below are contaminated with various substances and are planned for decontamination as part of the Decommissioning Project. They are therefore included in Category 6.

The *Reactor Building (#1111)* that housed the nuclear reactor remains a source of radiological contamination despite the fact that it was defueled in 1973. A recent Asbestos Containing Materials/Lead Based Paint/PCB Survey (ACM/LBP/PCB Survey) (Ref. #52) also discovered all three of these contaminant sources in the Reactor Building as well. The ACM/LBP/PCB Survey results were discussed in Section 4.2.7.

The *Reactor Hot Laboratory (#1112)* was used to handle irradiated materials and contains radiological contamination. In addition, the ACM/LBP/PCB Survey found ACM and PCB present in the building.

The *Reactor Services Equipment Building (#1131)* housed an active radiochemistry/analytical lab as well as currently housing diesel generators, a battery bank, and air compressors (Appendix C, Photos 5, 6, and 7). During the site visit, diesel fuel stains were observed on air compressors and surrounding concrete (Appendix C, Photo 8). The building also contains ACM, LBP and PCBs (Ref. #52).

The *Reactor Fan House (#1132)* contains pumps and compressors used in handling air from the hot areas. The 1987 Evaluation of the PBRF (Ref. #10) tested for radiological contamination throughout the facility and noted slight radiological contamination in the Fan House. The ACM/LBP/PCB Survey also found all three materials in the building.

The *Reactor Waste Handling Building (#1133)* houses the liquid waste evaporator system and a waste storage facility. The 1987 report stated that some low-level radiological contamination was found in the basement evaporator room. The ACM/LBP/PCB Survey also found LBP and PCBs in the building. Photo 18 in Appendix C shows only a single example of the long strips of peeling paint visible throughout the building.

The *Reactor Primary Pump House (#1134)* contains the primary cooling water pumping system and components, a pump pit, a hot sump, and resin pits (Appendix C, Photo 17). The Evaluation notes that the building contained radiological contamination and that a low-level radiological spill occurred near the resin pits, contaminating soil there. The ACM/LBP/PCB Survey also found LBP in the building.

The site visit to the *Reactor Compressor Building (#1136)* revealed oil staining on the compressors and concrete. LBP and PCBs were also found in the building during the survey (Ref. #52). Because radioactive materials were not handled in this building, it was not tested for radiological contamination during the 1987 Evaluation (Ref. #10).

The *Reactor Office and Laboratory Building (#1141)* contained repair shops, hot and cold sumps, offices and a radiochemistry lab. The 1987 Evaluation reports small radiological spills on the floor of rooms 212 and 214 that penetrated the cracks between the floor tiles (Ref. #10, #35). PCBs were also found in the building during the ACM/LBP/PCB Survey.

Both the *Cold Retention Basins (#1154)* and the *Hot Retention Area (#1155)* contain low levels of radiological contamination (Ref. #10).

The ACM/LBP/PCB Survey discovered LBP on the *Reactor Water Tower (#1151)*, the *Precipitator (#1157)*, and the remaining valve posts at the foundation of the removed *Reactor Cooling Tower (#1152)* through X-Ray Fluorescence tests, but did not take samples of the paint chips for further laboratory analysis (Ref. #52). Therefore, it is known that the paint contains lead, but the actual percent-by-weight is still unknown. This loose paint must be removed as LBP and disposed of as lead-containing waste prior to demolition of these structures. Analytical testing of the paint waste will be required at that time to determine if this waste is hazardous under RCRA (i.e., toxicity characteristic for lead, D008 waste).

Category 7

The Decommissioning Plan states that the *Reactor Water Effluent Monitoring Station (WEMS) (#1192)* has a small amount of silt, possibly with radiological contamination, accumulated between the weirs (Ref. #38). In addition, there is a potential for solvent contamination of these sediments as discussed in Section 5.2. This area therefore requires additional evaluation.

The *Reactor Sludge Basins (#1153)* and the *Drying Basins* (located outside the fence in the northern portion of the PBRF) were part of the raw water treatment system. For this reason, no radiological contamination is suspected. However, as discussed in Section 5.2, these areas have never been sampled. There is potential for water treatment chemicals such as algaecides to have accumulated in these areas and they therefore require further evaluation.

During the review of data conducted for this EBS, no information was found on the extent of the area of contamination from the 2 areas of low-level waste spills (just south of Building #1134 and south of Building #1133). Soils were sampled to a depth of 10 feet in the area south of the Waste Handling Building (#1133) in the 1985 characterization study, and contamination was reported to a depth of 6 feet. No direct indication of the areal extent of the contamination was given (It was stated that soil should be removed to a depth of 8 feet and that a total of 185 cubic yards of soil should be removed. Assuming a square excavation, this would imply an area of 25 feet on each side). No radiological concentration was reported in the 1985 study for the second spill area near the Primary Pump House (#1134). The 1998 survey confirmed the presence of contamination near the Waste Handling Building, but no contamination was detected at the previously identified spill area. The lateral extent of the spill near Building #1133 should be determined, and the presence or absence of contamination associated with the second spill should be verified.

4.8 ADJACENT PROPERTIES

As discussed in Section 1.1, the adjacent properties within the scope of this EBS are those within an approximately one-half mile radius of the PBRF boundary. These areas include a wooded area to the north within the Plum Brook Station boundary, residential areas adjacent to the northern boundary of the Station, and a mixture of open fields and wooded areas to the east, west, and south. With the exception of the residential area to the north, which is located about 0.6 miles from the Reactor Building at PBRF, all other adjacent areas are within the boundaries of Plum Brook Station. Aerial photos of the PBRF and surrounding areas are provided in Appendix B.

In addition to conducting a records search of existing data on the adjacent properties within the one-half mile radius, a "Vista Check" Federal and state database search for known sites within 1.5 miles of the PBRF was conducted. This report is customized to be in compliance with ASTM Standard E1527 (Phase I Environmental Site Assessments) and is attached as Appendix F of this EBSR.

A portion of the PBRF property and the area south of Pentolite Road was part of the Plum Brook Ordnance Works (PBOW) where 2,4,6-trinitrotoluene (TNT), dinitrotoluene (DNT) and pentolite were manufactured from 1941 to 1945. The activities conducted at the PBOW were discussed in detail in Section 3.1 of this EBSR. Within the adjacent properties one-half mile radius, five contaminated former PBOW sites are present. These sites, located south and southwest of the PBRF, are the Pentolite Road Red Water Ponds, the Garage Maintenance Area, the Rail Car Unloading Area/Sellite Area, Ash Pit #1 and Acid Area #3 (Figure 4.8-1).

Because the general groundwater flow direction at the PBS is towards the north, contaminated groundwater at these areas could potentially affect the environmental condition of the PBRF. In addition, contaminated soils present at these areas can act as an on-going source for groundwater contamination. The available data on these areas and conclusions on the likelihood of these areas affecting the PBRF are discussed below.

Methodology

Each of the contaminated sites within the PBRF adjacent area has been the subject of at least one environmental investigation. Different contractors or agencies, however, completed these investigations, in different years. In order to make the results easily readable, comparable and meaningful, this report compares all soil results to screening levels presented in EPA Region III's most recent (October 5, 2000) Risk Based Concentration (RBC) table. Contaminants included are VOCs, SVOCs, nitroaromatic compounds, and inorganics (Ref. #54). All surface and subsurface soil sample results are compared to $1/10^{th}$ of the RBCs for residential soil for noncarcinogenic contaminants. For example, a noncancer RBC for residential soil of 1 will be reduced to 0.1. This $1/10^{th}$ reduction is consistent with EPA Region III's risk screening criteria for potential Superfund sites and is done to ensure that chemicals with additive effects are not prematurely eliminated during screening (Ref. #54).

In order to estimate the potential for migration of contaminants in soil to groundwater, all surface and subsurface soil sample results are also compared to EPA Region III's Soil Screening Levels (SSLs) with a Dilution Attenuation Factor (DAF) of 1. As contaminants in soil percolate through soil to groundwater, they are subjected to physical, chemical and biological processes that tend to reduce their concentrations over time. According to EPA documentation, for waste areas of 10 acres or greater, a DAF of 10 or less is an appropriate threshold point (Ref. #24). SSLs with a DAF of 1 are used in this report and represent the most stringent threshold for which to measure sample results against. Only those sample results above $1/10^{th}$ RBCs or SSLs are discussed in this section.

All surface and groundwater sample results are compared to $1/10^{th}$ RBCs for tap water for noncarcinogenic contaminants. This comparison is made for the same reason as discussed above for soils. Only those sample results above $1/10^{th}$ RBCs are reported.

4.8.1 Pentolite Road Red Water Ponds

The Pentolite Road Red Water Ponds (PRRWPs) are located upgradient of the PBRF south of Pentolite Road (Figure 4.8-1). This site is approximately 425 feet from the southern boundary of the PBRF. It is the closest and most contaminated site to the PBRF in the adjacent area.

The PRRWPs initially consisted of two distinct basins or ponds, but the original shapes of the two ponds have shrunk significantly since they were originally constructed in 1941 and used in PBOW operations. Both ponds were subsequently filled in and little physical evidence of their former configuration remains (See Photos 8 and 9 in Appendix B). There are no buildings on the PRRWPs site.

4.8.1.1 *History*

PBOW Operational Period: 1941-1945

During the operational years of the PBOW, the PRRWPs received wastewater from TNT Manufacturing Areas A and B. This wastewater, referred to as “red water” because of its color, contained byproducts of the TNT manufacturing process, including nitroaromatic compounds. The PRRWPs consisted of two adjacent basins, a western and an eastern basin, each measuring approximately 100 feet wide by 140 feet long. The basins were constructed with precast 15 by 9-foot 9-inch blocks of concrete with asphaltic-filled expansion joints. The concrete was placed on 4 to 6 inches of gravel or #4 stone. A 1941 construction drawing for the PRRWPs indicated a one-foot high levee surrounding the basin (Ref. #26).

Review of historical site drawings indicate that wastewater from the wastewater settling basins at TNT Manufacturing Areas A and B flowed through wooden flumes and pipes to a wastewater treatment and incineration area (Waste Water Disposal Plant #1), then to the PRRWPs disposal area via an elevated 12-inch diameter discharge pipe (Figure 4.8.1.1-1) The Pentolite Road Red Water Ponds had a maximum capacity of 182,000 cubic yards of wastewater (approximately 36.9 million gallons) (Ref. #26).

Post PBOW Operational Period: 1945 to Present

Following World War II, the PBOW was in standby condition from 1945 to 1946. During this time, the Army began decontaminating and decommissioning many of the buildings and structures associated with the manufacturing of ordnance.

Removal and decontamination of TNT and DNT lines was conducted in 1945. Drain lines and steam lines were flushed and dismantled; PBOW historical records, however, do not indicate where they were flushed or where the water used for flushing was disposed (Ref. #21). Previous documentation does not state whether the limestone beds of the two basins were removed. From 1954 to 1958, Ravenna Arsenal, Inc. continued the decontamination efforts on the PBOW that the Army had begun in 1945 (Ref. #14). A letter to Ravenna Arsenal, Inc. from the U.S. Army Ammunition, Procurement, and Supply Agency in Joliet, Illinois describes work to be accomplished by Ravenna Arsenal, including apparent decontamination and decommissioning activities. Item 2 of this letter states: "Examine leaching bed near Reservoir #1, destroy some of the contaminants and re-route drainage to reduce amount of red water flowing into Plum Brook." The leaching bed referred to in this letter may be the Pentolite Road Red Water Ponds (Ref. #26).

An aerial photograph taken in October 1950 shows a disturbed area where the PRRWPs were located (Ref. #26). The eastern basin of the PRRWPs resembles the rectangular shape of the original wastewater basin and appears to be predominately dry. The western basin of the PRRWPs is irregularly shaped with its western corner overgrown with vegetation. The remainder of the western basin appears to contain water. An aerial photograph taken in 1956 shows a similarly shaped area for both the eastern and western basin of the PRRWPs, but the western basin, unlike in the 1950 photograph, appears to be predominately dry (Ref. #26).

4.8.1.2 *Physical Characteristics of the PRRWPs*

The terrain at the PRRWPs is relatively flat with an approximate elevation between 625 and 629 feet above MSL (Ref. #21). During field reconnaissance of the area conducted in March 1994 and fall 1994, the actual ponds were no longer present and the area consisted of thick masses of cattails with bare areas which seasonally contain ponded water (Ref. #19). Areas of stressed vegetation were also observed. Ponded water within this area, which occurs in topographical depressions, particularly after heavy rains, was observed to have a reddish tint (Ref. #21, #26).

A ditch, running southwest to northeast, traverses the PRRWPs area to the east. The ditch is approximately 10-feet deep. The water in the ditch flows in a northeasterly direction into Pentolite Ditch, which parallels Pentolite Road. According to information provided by NASA PBS employees, an underground clay pipe ("drainage tile") drains the PRRWPs area and discharges into the second ditch that parallels Pentolite Road (Ref. #26).

Groundwater flow in the PRRWPs area in both the overburden and bedrock aquifers has been documented to flow north (Ref. #26). The unconsolidated overburden, composed of glacial outwash material, varies in thickness from a few feet to over 40 feet. The bedrock consists of both limestone and shale. However, because of the shallow bedrock and thin veneer of overburden materials overlying the bedrock aquifer in the PRRWPs area, it is likely that the vertical, or downward, flow of groundwater from the overburden into the bedrock predominates over the horizontal flow in the overburden (Ref. #26). This flow pattern would facilitate migration of contaminants in the overburden soils and groundwater into the bedrock aquifer (Ref. #26).

4.8.1.3 *Contaminant Response Actions*

Four contaminant response actions by PBS personnel to incidents at the PRRWPs occurred. Prior to any specific environmental investigation of the PRRWPs, those contaminant response actions are summarized below.

1977 Actions

The first response action occurred in April 1977 when PBS personnel reported localized pockets of reddish brown water in the small surface ditch east of, and adjacent to, the PRRWPs (Ref. #26). The source was discovered to be a broken drain tile on the southeast corner of the ditch. Retention dikes and sump pits were promptly excavated to prevent leakage of the material to surface streams. From April 13, 1977 to May 3, 1977, a private disposal contractor removed approximately 60,000 gallons of the “red” water. Grading and drainage improvements were made to the area to alter surface runoff patterns (Ref. #26).

The local Air National Guard backfilled the original settling basin to bring it higher in elevation than the surrounding area. A new drainage ditch was dug approximately 300 feet east of the original ditch, which was then backfilled. The intent of these activities was to eliminate ponding in the area, thus reducing the amount of surface water that could mix with the red water residue, producing red-colored water (Ref. #26). A 1995 site management plan states that standing water still occurs in topographical depressions in the PRRWPs area (Ref. #21).

Surface water samples were collected from the surface drain tile pool and the retention trench that was dug to prevent runoff to surface streams. The samples were reported to be deep red in color and odorless, with a pH of 7.3 (Ref. #26). A flame test of the samples suggested the presence of sodium, which was subsequently verified by atomic absorption spectrophotometry to be present in a ratio of 2 to 1 to sulfate. This indicated that the major inorganic constituent is sodium sulfate, a by-product of the TNT process and a constituent of red water (Ref. #26).

Tannin and significant amounts of iron were also detected in the samples. The presence of tannin was attributed to an acid reaction with wooden vats and plumbing from PBOW structures. The presence of iron, in the range of 20 parts per million (ppm) was attributed to an acid/chemical reaction with iron plumbing from the PBOW structures. Phenols were also detected in the two samples but their source could not be explained (Ref. #26).

Surface and subsurface soil samples were collected in the drainage tile area. The depth of the surface soil sample was 0-1 foot. A thin layer (approximately 1/8-inch) of salt-like crystalline material was noted on the surface sample. The topsoil samples were dispersed in water and the water turned red in color. Subsurface samples of the clay sub-strata were also taken but the report does not give the depth of the sample. The subsurface samples did not cause discoloration of water. Analysis of the salt-like surface strata samples had the highest concentration of sulfate and the clay sub-strata apparently did not absorb the chemical spoils (Ref. #26).

1989 Actions

In 1989, NASA personnel observed reddish-brown water emanating from the drainage tile into Pentolite Ditch. Water samples were collected and analyzed for chemical oxygen demand (COD), pH, chromium, copper, lead, iron and zinc. The iron and COD concentrations were approximately 6 to 10 times higher at the discharge pipe than at the National Pollutant Discharge Elimination System (NPDES)-regulated sampling weir (outfall 003) located downstream on Plum Brook (Ref. #26).

1990 Actions

In April 1990, NASA personnel again observed rust-colored water discharging into Pentolite Ditch from the drainage tile that originates in the PRRWPs. Water samples were collected and analyzed for total chromium, COD, metals, and nitroaromatic compounds including cyclotrimethylene trinitranime (RDX) and cyclotetramethlene tetranitramine (HMX) known to be used in the manufacture of TNT during World War II. None of the NPDES limits for outfall 003 were exceeded as a result of the discharge. However, levels of iron, nickel, nitrate, sulfate and zinc at the outfall were significantly higher than the upstream levels as a result of the discharge. Concentrations of nitroaromatic compounds were below the detection limit of the analytical method (Ref. #22). The amount of red water released into the Pentolite Ditch is unknown, but the estimated flow rate during the 1990 release was five gallons per minute (Ref. #21).

1991 Actions

In April 1991, NASA personnel found a third discharge of rust-colored water into Pentolite Ditch from the drainage tile. Analysis of a NPDES sample collected 2 days later at a downstream location indicated levels for COD, suspended solids, nitrate, zinc, copper and pH to be within daily NPDES permit levels (Ref. #26).

The red water ponds are not inspected on a routine basis for overflow or discharge into streams or ditches (Ref. #21).

4.8.1.4 *Previous Environmental Investigations*

Two documented environmental investigations have been conducted at the PRRWPs: a Focused Remedial Investigation (RI) in 1997 (Ref. #26), and a Risk Assessment and Direct-Push Investigation in 1999 (Ref. #34). The PRRWPs were also included in the Site-Wide Groundwater Monitoring Report (Ref. #35).

In addition to the documented investigations, in 1994 a Site Inspection (SI) (Ref. #14) was conducted as a PBS-wide investigation. The PRRWP area was not specifically targeted, but a previous investigation is mentioned in this document. It is referred to as the site investigation conducted in 1990 by IT Corp. However, no reference list is provided in the 1994 SI, but data from the 1990 study are reproduced. It is reported that several nitroaromatics, including DNT, 2,4-DNT, and TNT were found in surface soils at the PRRWPs at concentrations up to 11,000 ppb. Trace volatile organic contamination was also noted. The 1990 study by IT was not located during the conduct of this EBS.

For the purposes of this report, a general comparison of soil samples from the 1997 Focused Remedial Investigation and the 1999 Risk Assessment and Direct-Push Investigation is given below to show changes in the prevalence of contaminants in the soil. A comparative review of groundwater samples is summarized from the 1999 Site-wide Groundwater Monitoring Report that compared overburden and bedrock groundwater samples from 1997 and 1998.

Sample Results

Comparison of Soil Samples for Nitroaromatic Compounds from the 1997 Focused RI and the 1999 Investigation

Soil samples for the 1997 investigation were taken in the fall of 1994 and the spring of 1995 and samples for the 1999 investigation were taken in 1998. The three-and-a-half to four-year time span between the two soil sample investigations seems to have made a difference in the number and concentrations of nitroaromatic compounds found in the soil in the PRRWPs area.

Each investigation examined a comparable number of soil samples: 18 surface (0 to 0.5 foot and 0 to 3 foot intervals) and 24 subsurface (3 to 5 foot and 5 to 10 foot intervals) soil samples in 1997 and 20 surface (0 to 2 foot interval) and 39 subsurface (4 to 6 foot and 8 to 10 foot) soil samples in 1999. For the discussion below, the general soil sample intervals are compared. For example, the 1997 3 to 5 foot samples were compared to the 1999 4 to 6 foot samples. Also, the samples are averaged so a single reading of a particular nitroaromatic compound is given for a particular soil interval. For the entire list of samples and their specific concentrations, see the source material, the 1997 Focused Remedial Investigation (Ref. #26) and the 1999 Risk Assessment and Direct-Push Investigation (Ref. #34).

The most common nitroaromatic compounds found in all intervals in both investigations were 2,4-dinitrotoluene (2,4-DNT), 2,6- dinitrotoluene (2,6-DNT), 1,3,5-trinitrobenzene (1,3,5-TNB), 1,3-dinitrobenzene (1,3-DNB) and 2,4,6-trinitrotoluene (2,4,6-TNT). In general, the number of samples containing nitroaromatic compounds increased with the depth of the sample. The concentrations of nitroaromatic compounds increased from the surface to the first subsurface sample, then decreased from the first subsurface sample to the second subsurface sample. This pattern indicates that the compounds have been migrating vertically through the soil, and are naturally degrading over time. The results are summarized in Table 4.8.1.4-1 below.

TABLE 4.8.1.4-1 — *A Comparison of Nitroaromatic Compounds found in Surface and Subsurface Soil Samples above RBC and SSLs from the 1997 and 1999 Investigations of the PRRWPs Area*

Nitroaromatic Compounds	RBC (1/10th) [mg/Kg]	# of samples detected 1997	# of samples above RBC	High 1997 [mg/Kg]	# of samples detected 1999	# of samples above RBC	High 1999 [mg/Kg]	SSLs (DAF 1) [mg/Kg]	# of samples above SSLs
Surface									
1,3-dinitrobenzene	0.78	5	**3**	1.6	0	NA	NA	0.0018	**All**
2,4-dinitrotoluene	16	9	0	2.1	2	0	1.2	0.029	**All**
2,6-dinitrotoluene	7.8	2	0	0.4	0	NA	NA	0.012	**All**
1,3,5-trinitrobenzne	230	5	0	1.7	0	0	NA	NA	NA
2,4,6-trinitrotoluene	2.1	0	NA	NA	1	0	0.3	NA	NA
First Subsurface									
1,3-dinitrobenzene	0.78	7	**7**	3.4	2	2	9.3	0.0018	**All**
2,4-dinitrotoluene	16	8	0	8.7	3	1	25	0.029	**All**
2,6-dinitrotoluene	7.8	4	0	3.6	2	0	0.29	0.012	**All**
1,3,5-trinitrobenzne	230	9	0	58	3	0	43	NA	NA
2,4,6-trinitrotoluene	2.1	1	**1**	12,000	0	NA	NA	NA	NA
Second Subsurface									
1,3-dinitrobenzene	0.78	11	**11**	6.6	3	3	5.8	0.0018	**All**
2,4-dinitrotoluene	16	10	**1**	19	6	0	15	0.029	**All**
2,6-dinitrotoluene	7.8	6	0	2.9	3	0	1.7	0.012	**All**
1,3,5-trinitrobenzne	230	12	0	23	6	0	18	NA	NA
2,4,6-trinitrotoluene	2.1	2	**1**	340	1	0	0.4	NA	NA

NA = Not Applicable

As the table details, only 2,6-DNT and 1,3,5-TNB are below RBC in all soil intervals. 1,3-DNB is above RBC in 3 out of 5 surface samples and in all subsurface samples. 2,4-DNT is above RBC only in 1 out of 10 second subsurface samples. The single sample of 2,4,6-TNT at 12,000 mg/Kg in the first subsurface interval was several orders of magnitude above its RBC of 2.1 mg/Kg. The sample was taken from the area believed to be where the red water entered the pond. No samples in this first subsurface interval with 2,4,6-TNT were detected in the 1999 investigation. Another sample of 2,4,6-TNT, measuring 340 mg/Kg, was above RBC in the second subsurface interval. This sample was also taken from where the red water entered the pond. The 1999 investigation only found a single reading of 2,4,6-TNT in this second subsurface interval, but it was below RBC.

When comparing the soil sample results to SSLs, it can be seen that al1 samples exceed SSLs for 1,3-DNB, 2,4-DNT and 2,6-DNT, indicating that it is likely these contaminants have migrated to groundwater. There are no SSLs for 1,3,5-TNB and 2,4,6-TNT.

It should be noted that 4-Am-DNT, a biologically transformed byproduct of dissolved TNT (by plants), was also found in three first interval and three second interval subsurface soil samples in the 1997 Focused Remedial Investigation (Ref. #26). This indicates that 2,4,6-trinitrotoluene is being transformed and broken down in the soil.

Additional Soil Testing in the 1999 Investigation

The 1999 investigation tested soil samples for PCBs, cyanide and metals. No PCBs or cyanide were found in any soil samples. A total of 59 surface and subsurface soil samples were taken to test for inorganic compounds. The surface soil samples were taken from the 0 to 2-foot range; the first subsurface samples were taken from the 4 to 6 foot range; and the second subsurface samples were taken from the 8 to 10 foot range. Twenty-one inorganic compounds were detected in at least one soil sample collected. Only those samples above RBC and SSLs are listed below in Table 4.8.1.4-2.

TABLE 4.8.1.4-2 — *Inorganics Found in Surface and Subsurface Soil Samples Above RBCs and SSLs from the 1999 Investigation of the PRRWPs Area*

Inorganic Compounds	RBC ($1/10^{th}$) [mg/Kg]	# of samples above RBC	Low	High	SSLs (DAF 1) [mg/Kg]	# of samples above SSLs
Surface						
Arsenic	0.43	20 (all)	2.3	14.1	0.0013	20 (all)
Chromium	23	None	NA	NA	2.1	20 (all)
Iron	2300	20 (all)	8330	22900	NA	NA
Manganese	1600	None	NA	NA	48	20 (all)
Selenium	39	None	NA	NA	0.95	2
First Subsurface						
Antimony	3.1	2	7.9	9.3	0.66	2
Arsenic	0.43	20 (all)	2.6	42.8	0.0013	20 (all)
Barium	550	None	NA	NA	110	4
Chromium	23	None	NA	NA	2.1	20 (all)
Iron	2300	20 (all)	9480	43700	NA	NA
Manganese	1600	2	2230	2270	48	20 (all)
Selenium	39	None	NA	NA	0.95	3
Second Subsurface						
Antimony	3.1	2	7.7	7.8	0.66	2
Arsenic	0.43	19 (all)	4.1	17.6	0.0031	19 (all)
Barium	550	None	NA	NA	110	1
Chromium	23	None	NA	NA	2.1	19 (all)
Iron	2300	19 (all)	8940	28700	NA	NA
Manganese	1600	None	NA	NA	48	19 (all)
Selenium	39	None	NA	NA	0.95	2

NA = Not Applicable

As the table details, all soil samples contained arsenic and iron above RBCs in all intervals. However, on-site background levels of arsenic, as measured during the 1997 Focused Remedial Investigation (Ref. #26), range between 3.5 mg/Kg to 23 mg/Kg, far above the arsenic RBC of 0.43 mg/Kg. While all surface and second subsurface samples were within the background arsenic range, four samples in the first subsurface level - 25.3mg/Kg, 27.3mg/Kg, 27.9mg/Kg and 42.8mg/Kg – were above the background range (Ref. #34).

Background levels for iron were not measured during the 1997 Focused RI, but in discussions with personnel at the Ohio Division of Geological Survey (Ref. #56), typical background levels for iron in northern Ohio can range from 10,000 mg/Kg to 50,000 mg/Kg, depending on the geology of the area. While a truly representative background level for iron should be determined from samples on-site, the background levels for iron given above would mean all iron concentrations detected are within the typical background range.

Antimony and manganese were detected in a limited number of samples above RBC in the subsurface soil. On-site background levels of antimony and manganese were established during the 1997 Focused RI with antimony ranging from 5.9 mg/Kg to 7.6 mg/Kg and manganese ranging from 86 mg/Kg to 1,500 mg/Kg (Ref. #26). First subsurface soil samples for both inorganic compounds exceed on-site background levels.

The inorganic compounds barium, chromium, selenium, while not above RBCs, were above SSLs, and therefore are likely to migrate to groundwater. Antimony, arsenic and manganese were also above SSLs. There is no SSLs for iron.

Overburden and Bedrock Groundwater Sample Results

According to the Site-Wide Groundwater Monitoring Report (Ref. #35), there are four overburden monitoring wells and one bedrock monitoring well in the PRRWPs area that were sampled for VOCs, SVOCs, nitroaromatic compounds, PCBs, metals (total and dissolved) and cyanide in 1997 and 1998. Figure 4.8.1.4-1 shows the location of the 5 monitoring wells in the PRRWPs area. Table 4.81.4-3 lists those samples above RBCs for both overburden and bedrock aquifers.

As the table details, only two VOCs in the overburden aquifer were detected at low concentrations. The bedrock aquifer sample, however, detected benzene at a concentration three orders of magnitude above RBC, and also had elevated levels of ethyl benzene and toluene. While BTEX compounds are known to naturally occur in the Delaware Limestone in central Ohio, and particularly in the Sandusky area (Ref. #55), the Site-Wide Groundwater Monitoring report concludes that BTEX concentrations found in the bedrock groundwater samples are above background levels (Ref. #35).

Elevated levels of SVOCs, nitroaromatic compounds, and metals, both in unfiltered and filtered samples, were detected in the overburden aquifer. The majority of the high concentrations were detected in two overburden monitoring wells, PR-MW7 and PR-MW8 (See Figure 4.8.1.4-1); these wells are located upgradient of the remaining two overburden monitoring wells, and are farthest from the PBRF. Those nitroaromatic compounds that exceeded SSLs for all soil samples, particularly 1,3-dinitrobenzene and 2,4-dinitrotoluene, were detected in high concentrations in the overburden aquifer in both the 1997 and 1998 samples. The inorganic compound manganese, which exceeded SSL for all soil samples, was also detected at high concentrations in all groundwater samples in both 1997 and 1998.

TABLE 4.8.1.4-3 — *A Comparison of Overburden and Bedrock Groundwater Samples above RBCs from 1997 and 1998*

Parameter	RBC (1/10th) [µg/L]	Overburden Aquifer: # of samples above RBC	Overburden Aquifer: 1997 Sample High	Overburden Aquifer: 1998 Sample High	Bedrock Aquifer: 1997 Sample High	Bedrock Aquifer: 1998 Sample High
VOCs						
1,1,2-Trichloroethane	0.19	0	NA	NA	NA	4.9
Benzene	0.32	1	NA	0.47	570	780
Bromodichloromethane	0.17	1	NA	0.23	NA	NA
Chlorobenzene	11	0	NA	NA	NA	5.5
Ethyl benzene	130	0	NA	NA	130	140
Toluene	75	0	NA	NA	490	550
SVOCs						
2,4-Dinitrophenol	7.3	3	6000	3800	NA	NA
3-Nitroaniline	11	2	450	NA	NA	NA
4,6-Dinitro-2-methylphenol	0.37	5	2300	20000	NA	NA
4-Nitrophenol	29	1	NA	42	NA	NA
Dibenzofuran	2.4	1	NA	620	NA	NA
Nitrobenzene	0.35	2	NA	13	NA	NA
Bis(2-Ethylhexyl)phthalate	4.8	NA	NA	NA	37	NA
Nitroaromatic Compounds						
1,3-dinitrobenzene	0.37	6	1500	2100	NA	NA
2,4-dinitrotoluene	7.3	6	1300	2400	NA	NA
2,6-dinitrotoluene	3.7	2	190	NA	NA	NA
1,3,5-trinitrobenzne	110	4	2000	2800	NA	NA
Metals (Unfiltered)						
Aluminum	3700	4	8960	15800	NA	NA
Arsenic	0.045	2	11.5	14.3	NA	NA
Barium	260	0	NA	NA	605	1710
Chromium	11	1	NA	22.6	NA	20.6
Cobalt	220	5	7270	7150	NA	NA
Copper	150	3	3790	3740	NA	NA
Iron	1100	3	22000	32600	NA	4810
Manganese	73	8 (all)	34100	43900	NA	139
Nickel	73	5	7600	6950	NA	NA
Metals (Filtered)						
Arsenic	0.045	1	12.5	NA	NA	NA
Barium	260	0	NA	NA	555	1390
Cobalt	220	5	6770	7450	NA	NA
Copper	150	5	3390	3900	NA	NA
Iron	1100	5	12200	9560	NA	NA
Manganese	73	8 (all)	29700	45500	NA	NA
Nickel	73	5	6820	7310	NA	NA
Thallium	0.26	0	NA	NA	NA	50.8
Cyanide	73	4	1710	1900	NA	NA

NA = Not Applicable

Note: Only one bedrock aquifer sample was collected in 1997 and 1998.

Bedrock groundwater samples for SVOCs, nitroaromatic compounds, and unfiltered and filtered metals either did not detect those contaminants or detected them below RBC. Only one SVOC, bis(2-Ethylhexyl)phthalate, was detected in the 1997 bedrock sample. Four inorganic compounds were detected in the unfiltered bedrock samples, but only barium was detected in the filtered sample as well. While barium was above its SSL for soil, it was not found in the overburden groundwater samples.

While the Site-Wide Groundwater Monitoring Report (Ref. #35) did not indicate finding any of the breakdown products of 2,4,6-dinitrotoluene, the 1997 Focused RI (Ref. #26) did report three biotransformation products, 4-Am-2-NT, 4-Am-DNT, and 2-Am-DNT, detected in overburden groundwater samples.

4.8.1.5 *Conclusions*

All previous environmental investigations into the PRRWPs concur that the area is heavily contaminated with significant levels of nitroaromatic compounds in both the soil and shallow groundwater. While extensive soil testing has delineated the extent of contamination in the PRRWPs soil, the number and placement of groundwater monitoring wells is inadequate to delineate the full extent of groundwater contamination in the overburden aquifer and the potential movement of contaminants toward the PBRF.

As shown in Figure 4.8.1.4-1 shows, there are no overburden monitoring wells located between the PRRWPs area and the PBRF, and overburden groundwater flow is north-northeast towards the PBRF. As discussed in Section 4.2.2.1, the overburden wells in the central portion of the PBRF were installed in association with the USTs at Building 1131 and have therefore not been sampled for nitroaromatics. There is no data on overburden aquifer quality between the PBRF and the PRRWPs. We therefore recommend that overburden monitoring wells be placed along the south side of Pentolite Road to determine if nitroaromatic contamination is migrating from the PRRWPs to the PBRF.

Additionally, there are no bedrock monitoring wells in the PRRWPs area. The bedrock monitoring well sampled in all groundwater studies is not on the PRRWPs site, but is located north of Pentolite Road (BED-MW15) and to the southeast of the PBRF (see Figure 4.8.1.4-1). We recommend that bedrock monitoring wells be placed in the PRRWPs area to delineate the extent of bedrock aquifer contamination in that area. As with the overburden aquifer, there is no data on bedrock aquifer quality between the PBRF and the PRRWPs. Since the PBRF is downgradient of the PRRWPs, we therefore recommend that bedrock monitoring wells be nested with the overburden wells along the south side of Pentolite Road to determine if contaminants are migrating in the bedrock aquifer from the PRRWPs to the PBRF. Suggested locations for these wells are presented in Section 4.8.6.

4.8.2 Garage and Maintenance Area

The Garage and Maintenance Area (GMA) is located upgradient of the PBRF in the southern-most portion of the adjacent area. It is approximately 2,000 feet from the southern boundary of the PBRF. The GMA consists of 4 buildings: Building # 7121 (Maintenance Shop) #7122

(Carpenter Shop), #7131 (Garage) and #7132 (Vehicle Service Station). The GMA is located in the central portion of the PBS with Maintenance Shop located along Maintenance Road and Garage located at the end of Garage Road. Railroad tracks from the TNT Rail Car Loading Area to the west of the GMA travel through the GMA and in front of Building 7121 (see Figure 4.8.2-1).

4.8.2.1 *History*

PBOW Operational Period: 1941-1945

The GMA was constructed in 1941 for PBOW operations and was likely used by the Army for maintenance of equipment and vehicles, possibly including rail cars (Ref. #19). Five underground storage tanks (USTs) were installed in the GMA in 1942 to support maintenance work. The USTs contained gasoline, solvents and waste oil. The GMA, as part of the PBOW, was shut down in September 1945.

Post PBOW Operational Period: 1945 to Present

The GMA was in a standby condition from 1945 to 1946. When NASA acquired the PBS in 1963, it reopened the GMA and continues to use it today as a vehicle maintenance area. In 1964, NASA installed 3 USTs (#29, #30 and #31) at the GMA for the storage of solvents (acetone, TCE and TCA), and a fourth (#36) UST in 1982 for the storage of diesel fuel (Ref. #21).

4.8.2.2 *Physical Characteristics of the GMA*

The terrain at the GMA is flat with an average elevation of approximately 635 feet above MSL. The GMA is located partly in grassland and partly in a "structured" paved area (Ref. #21). Surface water runs off of the GMA either toward the east flowing into Plum Brook or toward the west flowing into Ransom Brook. The Site-Wide Groundwater Monitoring investigation found that groundwater in both overburden and bedrock flows to the north-northeast, which is toward the PBRF (Ref. #35). Groundwater flow was calculated to be 1.9 to 3.4 feet per year (Ref. #13).

4.8.2.3 *Previous Environmental Investigations*

Three environmental investigations have occurred at the GMA; two under RCRA and one under the DERP/FUDS program. A UST Corrective Actions Remedial Investigation/Feasibility Study (RI/FS) was conducted under RCRA in 1991, as was a site investigation/risk assessment supporting closure of the UST sites in 1999. A Limited Site Investigation was also conducted in 1999 under the DERP/FUDS program. These investigations are summarized below.

<u>1991 UST Corrective Actions RI/FS</u>

The 1991 UST Corrective Actions RI/FS was conducted for the entire PBS site and included tank removals from the GMA (Ref. #13). A total of 8 USTs were removed from the GMA area in 1989. Table 4.8.2.3-1 below lists the GMA tanks removed. The location, size, contents and final disposition of the ninth UST #36, installed in 1982, is unclear from a review of previous documentation on the GMA (Ref. #s 12, 13, 16, 21).

The RI/FS specifically tested the soil surrounding, and water in the former tank area and also tested soil and groundwater over the entire GMA site. Gasoline and diesel fuel tank-related samples were compared to Ohio EPA standards for benzene, toluene, ethylbenzene and xylene (BTEX) and total petroleum hydrocarbons (TPH) concentrations. VOC concentrations are measured against EPA Region III $1/10^{th}$ RBC standards. Results and remedial actions are summarized below.

TABLE 4.8.2.3-1 — *Relevant Information Relating to the Removal of 8 USTs from the GMA*

Date of Installation	Date of Removal	Building #	Tank #	Tank Capacity and Material	Tank Contents	Tank Status at Time of Removal
1942	9/18/89	7121	28	3,000-gallon steel tank	Waste oil and solvents	No information provided
1964	9/18/89	7121	29	700-gallon steel tank	Solvents	Tank found to contain water prior to removal
1964	9/18/89	7121	30	700-gallon steel tank	Solvents	Tank found to contain water prior to removal
1964	9/18/89	7121	31	700-gallon steel tank	Solvents	Tank found to contain water prior to removal
1942	9/18/90	7131	32	1,500-gallon steel tank	Waste oil and solvents	No information provided
1942	7/5/89	7132	33	9,000-gallon steel tank	Gasoline	Tank removed from service earlier due to suspected leakage
1942	7/5/89	7132	34	9,000-gallon steel tank	Gasoline	In service prior to week of removal
1942	7/5/89	7132	35	9,000-gallon steel tank	Diesel Fuel	Tank removed from service earlier due to suspected leakage

Sample Results

Tank Samples – Soil, Surface Water and Groundwater
Building 7132, Vehicle Service Station - Tanks #33, #34, #35

The tanks (#33, #34, and #35) for the Vehicle Service Station were suspected of leaking prior to removal and inspection of the tanks and sampling of the area proved this true. Visible areas of corrosion were noted on the three tanks removed from the Vehicle Service Station that held gasoline and diesel fuel. Three soil samples from the tank pit bottom, and one sample from walls, excavated piles, and adjacent Pump Island were tested for BTEX, TPH, EP Toxicity Lead and ignitability. Surface and groundwater samples were also taken from the tank pit bottom and tested. Only those results above Ohio EPA standards are presented in Table 4.8.2.3-2 below. For a review of all results, see Ref. #13.

The most prevalent BTEX contaminant detected was benzene, found not only at concentrations several orders of magnitude above its Ohio EPA standard in the pit bottom and Pump Island soil samples, but also above the standard in the soil borings and standing water samples. All pit bottom and Pump Island samples were above the standard for BTEX and TPH. Based on these findings, 13 additional feet of soil was removed from bottom of the already excavated tank pit, as well as soil from the tank pit walls, and soil around the former location of the Pump Islands to prevent further contamination of the area (Ref. #13). A subsequent soil sample from the tank area contained benzene at 420 μg/L. After discussions with the Ohio State Bureau of Underground Storage Tank Regulation, it was determined that an additional 1-1.5 feet of soil would be removed from the tank pit bottom before the excavation was backfilled. This additional excavating was completed and the tank pit was backfilled (Ref. #13).

TABLE 4.8.2.3-2 — *Soil and Standing Water Samples Taken From the Excavation Pit at Vehicle Service Station Tank Area*

		Pit Bottom Soil Samples		Pump Is. Soil Samples	Soil Pile Samples		Soil Borings Samples		Standing Water Samples	
Parameter	Ohio EPA Stnds	Sample Low	Sample High	Sample	Sample Low	Sample High	Sample Low	Sample High	Sample High	Sample Low
BTEX [µg/Kg]										
Benzene	6	120	43000	2800	NA	NA	14.42	15.03	NA	55
Toluene	4000	8700	30000	54000	NA	NA	NA	NA	NA	NA
Ethylbenzene	6000	NA	11000	47000	NA	NA	NA	NA	NA	NA
Xylene	28000	NA	96000	400000	NA	NA	NA	NA	NA	NA
TPH [mg/Kg]										
TPH	40*	48.5	616.6	2817	67	621	NA	51	NA	56.2

*Standard at the time of this investigation.

Building 7121, Maintenance Shop - Tanks #28, #29, #30 and #31

Three soil samples from the tank pit bottom, and one sample from walls and excavated piles were taken after the removal of the four tanks (#28, #29, #30 and #31) from the Maintenance Shop that held waste oil and solvents. Soils around the tanks were tested for VOCs, TPH, EP Toxicity Lead and ignitability. The soils around the area of Tank #28 revealed a greater number of contaminants and at higher concentrations than the soils around Tanks #29, #30, and #31. Trichloroethene, 1,1,1-trichloroethane and tetrachloroethene were the VOCs with the highest concentrations in all samples, but all detected levels were below RBC (Ref. #13). They were, however, above SSLs. The documentation does not indicate that any soils were removed from the area.

Building 7131, Garage – Tank #32

Three soil samples from the tank pit bottom, and one sample from walls and excavated piles were taken after the removal of the one tank (#32) from the garage that held waste oil and solvents. Soils around the tanks were tested for VOCs, TPH, EP Toxicity Lead and ignitability.

All samples were below RBC for VOCs. The TPH level of 244 mg/Kg was above the Ohio EPA standard of 40 mg/Kg that was applicable at that time (Ref. #13). The documentation does not indicate that any soils were removed from the area.

Samples for Entire GMA

Soil Gas Survey

A soil gas survey of the GMA was done in 1989 at the time of the UST removals. A total of 76 samples were collected and analyzed. Most areas sampled showed measurable levels of one or more of the target compounds: dichloroethene (DCE), benzene, trichloroethene (TCE), toluene, tetrachlorethene (PCE) and xylene. The highest concentrations were found near the former UST locations and along building foundations, railroad tracks and buried utility lines. The report theorizes that these structures and features could be serving as preferential migration pathways for the movement of contaminants (Ref. #13).

Soil samples ranging in depth from 4 to 12 feet below the ground surface were collected north and northwest of the GMA. Sample results indicated low levels of contamination from fuel products, TCE and PCE. The distribution of the contaminants detected appears to be sporadic, indicating that low-level soil or groundwater contamination may be present (Ref. #13).

Groundwater

Two groundwater samples were taken. It is unclear from the report whether the groundwater samples were taken from the overburden or bedrock aquifer (Ref. #13). Samples were tested for VOCs, SVOCs, pesticides, PCBs and TPH. No SVOCs above RBCs were detected in the samples. Only two VOCs were detected above RBCs: 1,1-dichloroethene was detected at 20 μg/L (RBC 0.04 μg/L) and trichloroethene was detected at 7 μg/L (RBC 1.6 μg/L). Trace levels of Beta-BHC were detected in both samples. Beta benzene hexachloride (BHC) is a common insecticide. The detection of Beta BHC is not linked to the contents of former USTs (Ref. #13).

Sediment

Two sediment samples were taken from drainage ditches, one east of the northeast corner of the Maintenance Shop and one north of the Garage. These drainage ditches channel water from the former UST areas toward the east (Ref. #13). Samples were tested for VOCs, SVOCs, pesticides, PCBs and TPH. Two VOCs, methylene chloride and acetone, were detected about $1/10^{th}$ RBC for tap water, but the RI/FS concludes that these VOC concentrations were probably laboratory contaminants, not contaminants from past activities at the site (Ref. #13). One VOC, 1,1-dichloroethane, was found in one sample but below RBC. The report states this in an uncommon finding and attributes it to ice and moisture contained in the sediment sample. The report does point out, however, that 1,1-dichloroethane was detected in both the groundwater and surface soil samples (Ref. #13).

Several SVOCs were detected in both sediment samples but were below RBC and SSLs. The RI/FS concludes that these SVOCs, polycyclic aromatic hydrocarbons (PAHs), were from roadway run-off, gasoline and diesel vehicle tailpipe emissions, not from the contents of the former USTs. Two pesticide compounds, Beta BHC at 82 μg/Kg and Delta BHC at 370 μg/Kg, were also detected in the sediment samples. Sediment samples showed TPH at 2620 mg/Kg, two orders of magnitude above the Ohio EPA standard for TPH of 40 mg/Kg that was applicable at that time.

1997/1998 Site-Wide Groundwater Monitoring Investigation

Since the RI/FS study was conducted almost a decade ago, more recent groundwater results from the Site-Wide Groundwater Monitoring Report (Ref. #35) were reviewed to determine current contaminant levels. One overburden and one bedrock monitoring well were installed in the GMA. The groundwater samples were tested for VOCs, SVOCs, metals (unfiltered and filtered), nitroaromatic compounds, PCBs, and cyanide. Only those results above RBCs are discussed below.

In the overburden aquifer, only one VOC, 1,1-dichloroethene, was detected above RBC (0.044 μg/L) in both the 1997 (3.4 μg/L) and 1998 (2.2 μg/L) samples. Seven unfiltered metals (aluminum, arsenic chromium, iron, lead, manganese and vanadium) were detected above RBCs in the overburden aquifer in the 1998 samples. The metals were not detected in the 1997 overburden aquifer (Ref. #35).

In the bedrock aquifer, one VOC, benzene, was detected at 19 μg/L in the 1998 sample, well above its RBC of 0.32 μg/L. Similarly, one nitroaromatic compound, 1,3-dinitrobenzene at 0.86 μg/L, was detected above its RBC of 0.37 μg/L. Barium and manganese were detected above RBCs in both the unfiltered and filtered 1997 and 1998 samples. The 1997 sample also showed unfiltered iron above its RBC (Ref. #35).

Limited Site Inspection in 1999

A Limited Site Inspection was conducted in 1999 at the GMA as part of the DERP/FUDS program (Ref. # 46). The purpose of this study was to evaluate the potential contamination specifically at the Locomotive Shop within the GMA due to past Army activities.

One soil sample was taken in a work pit within the Locomotive Shop and one soil sample was taken outside the Locomotive Shop near the wastewater junction box. The samples were analyzed for SVOCs, PCBs, and metals. The only detects of note in the sample from the pit were the PCB Aroclor 1260 at a concentration of up to 450 mg/kg, lead up to 1,330 mg/kg, antimony at 10.9 mg/kg, and chromium up to 148 mg/kg. The sample near the wastewater junction box had no significant detects.

Water samples were collected from the sump inside the Locomotive Shop and the wastewater junction box outside the Locomotive Shop. Surface water samples and a sediment sample from an open ditch to the east of the building were also taken. The samples taken within the sump were found to have iron levels of 29,300 ug/L, lead levels of 177 ug/L, and arsenic levels of 20.6 ug/L. No evidence of contamination was found outside the building.

No groundwater samples were taken as part of this site inspection.

<u>Studies Conducted in 1999 Associated with Closure of the USTs</u>

As part of the closure process for the UST sites at the GMA, another site investigation was conducted in 1999. The objective was to determine the presence and extent of chemical contamination, and use this data to conduct a human health risk assessment. The results of these studies were summarized in an Amended Closure Plan (Ref. # 39).

Soil samples from borings detected 59 organic chemicals of potential concern at the Building 7121 location and 35 at the Building 7131 location. The borings also detected levels of lead higher than normal background levels for the area. Therefore, lead was also identified as an inorganic chemical of potential concern for Building 7131.

Excess cancer risk estimates were calculated from the estimated daily intakes and cancer slope factors and compared to the OEPA's recommended risk guideline of 1E-05. Excess cancer risks for populations evaluated for the Building 7121 exposure area ranged from 1E-05 for a child to 2E-05 for an adult, and from 1E-06 for a child to 2E-05 for an adult for the Building 7131 exposure area. Non-cancer health effects were determined to be below one (ranging from 0.004 to 0.2 at both sites) on the OEPA Hazard Index and thus did not require remediation.

Cancer risks were found to be above the OEPA action level for polynuclear aromatic hydrocarbons detected along the Garage Road in shallow soil. However, these detections are not attributable to UST releases, and were attributed to the historical use of oil along the roadways at PBS. Therefore soil remediation under this program was not warranted.

It was determined, however, that corrective action was required to address the presence of dissolved-phase VOCs in shallow groundwater in the vicinity of the Building 7121 USTs. The selected remediation system will consist of a vacuum-enhanced groundwater recovery system, with groundwater discharged to the sanitary sewer and extracted vapors discharged to the atmosphere. The effectiveness of the system will be assessed by soil and groundwater sampling.

4.8.2.4 *Conclusions*

The removal of USTs and contaminated soils surrounding the tanks from the GMA eliminated the majority of the sources of contamination in GMA soils and groundwater. It is specifically the groundwater contamination, and its subsequent movement toward the PBRF, that is relevant to this report. The groundwater treatment system discussed above should aid both in reducing organic contaminant levels and also in preventing the migration of contaminated groundwater.

While the 1991 RI/FS (Ref. #13) detected little groundwater contamination in GMA, the 1997/1998 Site-Wide Groundwater Monitoring Report (Ref. #35) detected a number of metals at levels above RBCs in both the overburden and bedrock aquifers. However, metals are naturally occurring in groundwater and there are no data on typical background levels of metals in groundwater at the PBS. Therefore, it is uncertain whether the concentrations detected reflect contamination from past activities or are naturally occurring.

As recommended in the previous section on the PRRWPs, the installation and sampling of overburden and bedrock monitoring wells just south of Pentolite Road, upgradient of the PBRF, would confirm if contaminant migration from the GMA toward the PBRF is occurring.

The 1991 RI/FS concluded from the soil gas survey that migration of contaminants has occurred along preferential flow pathways associated with man-made structures on the GMA. According to sitewide PBS engineering drawings, a sanitary sewer line is present approximately 300 feet west of the GMA. This line runs north to the PBRF (see Appendix D for the utility line drawings). It is possible that contaminants could migrate along this pathway to the PBRF. We recommend soil and groundwater screening sampling along this sanitary sewer line to ascertain if contaminants are migrating towards the PBRF.

4.8.3 Rail Car Unloading Area/Sellite Area

The Rail Car Unloading Area/Sellite Area (RCUA/SA) is located upgradient of the PBRF, directly west of the GMA approximately 2,000 feet from the southern boundary of the PBRF. It is located on the north side of Maintenance Road between Ransom and Taylor Roads (see Figure 4.8.2-1). The RCUA/SA has been described as covering an area of 1 acre (Ref. #12) to 5 acres (Ref. #14). The Rail Car Unloading Area and Sellite Area are separate areas. The Sellite Area is located adjacent to the west side of the Rail Car Unloading Area. The 1995 Site Management Plan (Ref. #19) states that the Sellite Area may have contributed to the contamination of the site and therefore is included with the Rail Car Unloading Area.

There are no buildings currently on the RCUA/SA. Broken timbers found near the Sellite Area suggest the former presence of a wooden structure, which has been confirmed by historic photographs (Ref. #21). An abandoned single railroad track is located on the northern and western portions of the site.

4.8.3.1 *History*

PBOW Operational Period: 1941-1945

The RCUA/SA was constructed in 1941 and actively used until the production of TNT ceased two weeks after V-J Day (September 2, 1945). The RCUA received and unloaded more than 400 million pounds of toluene (Ref. #12). It is suspected that additional chemicals may have been unloaded or stored at the RCUA (Ref. #21).

The Sellite Area was used for the production and storage of sellite used in the manufacture of TNT. Sellite, more commonly known as sodium sulfate, was added to crystalline TNT because it forms a water-soluble salt with unwanted TNT isomers that are removed in the water wash process.

Post PBOW Operational Period: 1945 to Present

The RCUA/SA was in a standby condition from 1945 to 1946 after TNT manufacturing ceased. While decommissioning on the entire PBOW site began in 1946, it is believed that the RCUA, with its proximity to the GMA, may have led to its use for informal staging of equipment and supplies (Ref. #21). Based on historic photographs, the building on the RCUA/SA site was removed sometime after 1958, but remnants of the site remain, including cinders (slag) and sulfur (Ref. #21).

4.8.3.2 *Physical Characteristics of the RCUA/SA*

The terrain at the RCUA/SA is relatively flat with a gentle northward slope. Elevation is approximately 635 feet above MSL. The RCUA/SA is located on grassland with lush vegetation surrounding the area. The 1991 Preliminary Assessment found approximately a quarter acre of bare area that supported little vegetation. The report hypothesized that the area may be bare due to toluene spills during the unloading process in the Operational Period (1941-1945) (Ref. #12). A subsequent 1994 field reconnaissance found extensive areas of bare soil in the Sellite Area with pieces of sulfur and slag on the ground (Ref. #20).

Surface runoff at the RCUA generally flows north to drainage ditches or streams. A tributary of Ransom Brook passes west of the site and flows northward toward the edge of the PBRF and then off the PBS. A shallow surface water ditch, located to the east, receives run-off from the Sellite Area (Ref. #21). Groundwater in the overburden aquifer was measured to flow in a northerly direction under the RCUA/SA. No aquifer tests have been conducted at the RCUA/SA (Ref. #21).

4.8.3.3 *Previous Environmental Investigations*

The 1994 Site Inspection is the only investigation conducted that covers the RCUA/SA (Ref. #14). The RCUA/SA was only a small part of that investigation. The results of the samples that were taken on the RCUA/SA are summarized below. The Site-wide Groundwater Monitoring Report (Ref. #32) does not indicate there are any monitoring wells on the RCUA/SA.

Sample Results

Surface and Subsurface Soil

Two surface soil samples were collected near the RCUA west of the GMA, north of Maintenance Road and three surface soil samples were collected from the SA just west of the RCUA near the intersection of Maintenance Road and the abandoned rail spur. One subsurface soil sample was taken in the RCUA but the depth of the sample was not given in the report (Ref. #19). No subsurface soil samples were taken in the SA. The samples were tested for VOCs and SVOCs. Table 4.8.3.3-1 below details only those contaminants found above RBCs and SSLs.

TABLE 4.8.3.3-1 — *Results of Surface and Subsurface Soil Samples Taken From the RCUA and SA Sites*

	RBC ($1/10^{th}$) [µg/Kg]	RCUA above RBC samples	SA above RBC samples	SSLs DAF 1 [µg/Kg]	RCUA above SSLs samples	SA above SSLs samples
Surface Soil						
Benzo(a)anthracene	870	NA	920	73	NA	220 / 920 /89
Benzo(a)pyrene	87	NA	680	19	22	130 / 920
Benzo(b)fluoranthene	870	NA	2400	23	34	310 / 2400
Dibenzo(a,h)anthracene	87	NA	91	70	NA	91
Indeno(1,2,3-cd)pyrene	870	NA	NA	64	NA	85 / 430
Toluene	1,600,000	NA	NA	44	NA	54 / 82
Trichloroethene	5800	NA	NA	0.7	NA	1 / 1
		RCUA Sample	**SA Samples**			
Acenaphthylene	No RBC	NA	98	No SSL		
Phenanthrene	No RBC	25	110 / 460 /48	No SSL		
Subsurface Soil						
Benzo(a)pyrene	87	230	No SA samples	19	230	No SA samples
Benzo(b)fluoranthene	870	NA		23	340	
		RCUA Sample				
Acenaphthylene	No RBC	60	No SA samples	No SSL		
Phenanthrene	No RBC	220		No SSL		

NA = Not Applicable

As Table 4.8.3.3-1 shows, the SA has more contaminants and contaminants at higher concentrations than the RCUA. While there were no surface soil samples from the RCUA above RBCs, four samples were detected above RBCs in the SA. Similarly, while only two surface soil samples were detected above SSLs in the RCUA, fourteen samples were detected above SSLs in the SA. The single subsurface soil sample in the RCUA detected only two contaminants above RBCs and SSLs, but these contaminants were found at higher concentrations than in the surface soil samples.

Groundwater

One groundwater sample was taken from the overburden monitoring well installed along the western edge of the GMA near the RCUA. Solvents and SVOCs were detected in the sample but are believed to be related to the UST leakage on the GMA, not from any contamination on the RCUA/SA. Only one solvent, 1,1-dichloroethene at 8 μg/L, was detected above the EPA Region III tap water RBC of 0.044 μg/L.

Sediment and Surface Water

One sediment sample and one surface water sample were collected in Ransom Brook adjacent to the RCUA. Based on topography, this location was selected as a possible entry to surface water for contaminants from surface water runoff from the RCUA (Ref. #21). No organic compounds were detected in the surface water samples. VOCs and SVOCs were detected in the sediments but most were estimated values below the potential quantitation limit (Ref. #21).

4.8.3.4 *Conclusions*

Because of the limited scope of the 1994 Site Investigation at the RCUA/SA, no conclusions were made regarding this site in that report (Ref. #14). The 1991 Preliminary Investigation (Ref. #12) conducted a hazard ranking on the RCUA. It scored between 3.84 to 9.70 for the various transport pathways, well below the EPA-designated hazard ranking score of 28.5, the point at which a site becomes eligible for inclusion in the National Priorities List (NPL) (Ref. #21).

Because so few soil or groundwater samples were taken, it is difficult to come to any conclusions about the RCUA/SA and the possible effect that it could have on the PBRF. Given that contaminated groundwater is the most likely contaminant source on the RCUA/SA to affect the PBRF, it is likely that the groundwater monitoring wells recommended to be installed upgradient of the PBRF would be sufficient to determine if contaminant migration is occurring from the RCUA/SA and if it is likely to affect the PBRF.

4.8.4 Ash Pit #1

Ash Pit #1 is located upgradient of the PBRF in the southern-most portion of the adjacent area of the PBRF. Ash Pit #1 is just south of Maintenance Road, southeast of the GMA and north of the railroad tracks and Building #8531 (Power House #1) (Figure 4.8.4-1) (Ref. #21). It is approximately 2,025 feet from the PBRF boundary. The northern and southern boundaries of Ash Pit #1 are still somewhat defined by berms or rises in elevation approximately 3 to 5 feet higher than ground level. The northern and southern berms transverse in an east/west direction along Maintenance Road and Power House #1, respectively (Figure 4.8.4-1) (Ref. #45). The eastern and western boundaries of Ash Pit #1 are not clearly defined by a berm or rise in elevation but have been identified from historic aerial photographs and drawings (Ref. #21, #45).

4.8.4.1 *History*

PBOW Operational Period: 1941-1945

During the PBOW operational period, Ash Pit #1 served as a disposal area for ash generated at the on-site power plant, Power House #1 (Ref. #21). Power House #1 consisted of a main powerhouse, a coal storage area, and a diked area containing fuel oil in above ground storage tanks (ASTs). The main powerhouse consisted of two to four large coal burning boilers, several steam driven or electric air compressors, a turboelectric generator, and a feed water treatment system. Water was added to the coal ash generated from each of the boilers. The water/ash slurry flowed through a sluice trench to the ash sump located at the end of the building. From the ash sump, the ash traveled through a pipeline to a nearby surface impoundment known as Ash Pit #1 (Ref. #45).

Post PBOW Operational Period: 1945 to Present

Information concerning the status or use of Ash Pit #1 following the end of the TNT manufacturing operation is limited (Ref. #21). Unlike other areas of the PBOW, the railroad tracks and Power House #1 were not destroyed during the decommissioning of the PBOW but remain abandoned at the site. Based on topographical quadrangles (dated 1959 and 1969), aerial photographs, and a visual site survey, the area of Ash Pit #1 has essentially remained unchanged since the PBOW operational period (Ref. #45).

4.8.4.2 *Physical Characteristics of Ash Pit #1*

The terrain of Ash Pit #1 is relatively flat with an average elevation of approximately 635 feet above MSL. The elevated berms that define the northern and southern boundaries of Ash Pit #1 are approximately 640 feet MSL (Ref. #45). A visual survey on July 8, 1999 found Ash Pit #1 covered with thickets of grass, weeds and small trees ranging from 5 to 8 feet tall (Ref. #45).

Two drainage ditches were found near Ash Pit #1. The first drainage ditch, approximately 5 feet north of Ash Pit #1 on the northern boundary of the pit, runs in a northerly direction and under Maintenance Road by means of a concrete culvert. The visual survey report notes that the ditch was overgrown with vegetation and that access was limited (Ref. #45). The ditch did not appear to contain any water. A second, larger drainage ditch located northwest of Ash Pit #1 did contain water that was flowing in a northeastern direction (Ref. #45).

Groundwater flow under Ash Pit #1 is in a north to northeast direction (Ref. #21).

It should be noted that a high voltage utility line runs through Ash Pit #1 in a north-south direction. There is also an underground telephone line running approximately 5 feet south of Maintenance Road in an east-west direction just north of Ash Pit #1 (Ref. #45).

4.8.4.3 *Previous Environmental Investigations*

In July 2000, a Limited Site Investigation was conducted on Ash Pit # 1 (Ref. #45). The Site-wide Groundwater Report (Ref. #35) does not indicate there are any monitoring wells the Ash Pit #1 area. No groundwater samples have been collected at Ash Pit #1.

Sample Results

Surface and Subsurface Soil

A total of one surface sample and 6 subsurface samples were taken. The subsurface samples ranged from 1 to 4 feet in depth. All samples were analyzed for SVOCs and target analyte metals (TAL) metals (Ref. #45). No SVOCs were found in any of the soil samples. Several metals above RBC and SSLs were detected and are listed below in Table 4.8.4.3-1.

TABLE 4.8.4.3-1 — *TAL Metals Found in Surface and Subsurface Soil Samples above RBCs and SSLs From Ash Pit #1*

TAL Metals	RBC (1/10th) mg/Kg	# of samples above RBC	Low	High	SSLs DAF 1 mg/Kg	# of samples above SSLs
Surface						
Aluminum	7800	1		16600	NA	NA
Arsenic	0.43	1		31.2	0.0013	1
Chromium	23	None	NA	NA	2.1	1
Iron	2300	1		73200	NA	NA
Manganese	1600	None	NA	NA	48	1
Selenium	39	None	NA	NA	0.95	1
Subsurface						
Aluminum	7800	4	8310	12700	NA	NA
Arsenic	0.43	6 (all)	6.2	19.6	0.0013	6 (all)
Barium	550	None	NA	NA	110	1
Chromium	23	None	NA	NA	2.1	6 (all)
Iron	2300	6 (all)	18500	95100	NA	NA
Manganese	1600	2	2230	2270	48	6 (all)
Selenium	39	None	NA	NA	0.95	4

NA = Not Applicable

As the table details, aluminum, arsenic and iron were found above RBC in both the surface and subsurface samples. Manganese was above RBC only in the subsurface sample. Arsenic, chromium, manganese, and selenium were above SSLs in surface and subsurface samples, increasing in concentration in the subsurface samples. Additionally, barium was found above SSLs in the subsurface sample. Again, it is likely that contaminants above SSLs will be found in groundwater (Ref. #45).

Surface Water and Sediment

One surface water and one sediment sample were collected from the drainage ditch northwest of Ash Pit #1. The samples were analyzed for SVOCs and target analyte metals (TAL) metals (Ref. #45). No SVOCs were found in the water or sediment samples. Several TAL metals were found in both sediment and surface water samples above RBCs and are shown in Table 4.8.4.3-2 below.

As with the soil samples, aluminum, arsenic and iron were found in the sediment samples above RBCs and SSLs. Additionally, chromium, manganese and vanadium were detected above SSLs in the sediment sample. The surface water sample detected only two metals, iron and manganese, above RBCs (Ref. #45).

TABLE 4.8.4.3-2 — *TAL Metals Found in Sediment and Surface Water Samples above RBCs and SSLs From Ash Pit #1*

TAL Metals	RBC ($1/10^{th}$) [mg/Kg]	SSLs (DAF 1) [mg/Kg]	Sample
Sediment			
Aluminum	7800	NA	11400
Arsenic	0.43	0.0013	41.5
Chromium	23	2.1	NA
Iron	2300	NA	80900
Manganese	1600	48	1730
Vanadium	55	260	73.5
	RBC ($1/10^{th}$) [μg/L]		**Sample**
Surface Water			
Iron	1100		1390
Manganese	73		78.8

4.8.4.4 *Conclusions*

With findings of elevated metals at Ash Pit #1, the Limited Site Investigation concludes that it is possible that past DoD activities at the Ash Pit have negatively impacted the environment (Ref. #45). Given the limited number of samples collected and the lack of groundwater data, it is not possible to determine if contaminants at Ash Pit #1 may affect the PBRF.

As ash slurry (coal ash and water) was the only waste stream put into Ash Pit #1, it is unlikely that there are any contaminants other than TAL metals in the soil or groundwater. SVOCs and VOCs are burned off when the coal was burned to produce energy. All sample results were negative for SVOCs, supporting this fact. While metals are generally not mobile in soil, more than 50 years have past since the ash pit was active; metals may have migrated into the groundwater, particularly arsenic and manganese that were found at concentrations above the SSLs.

However, natural background levels of certain metals are known to be elevated in northern Ohio. Background levels for iron range between 10,000 mg/Kg and 50,000 mg/Kg (Ref. #56) and for manganese range from 86 mg/Kg to 1,500 mg/Kg (Ref. #26). The subsurface soil sample for iron was 95,100 mg/Kg and the manganese subsurface soil sample was 2,270 mg/Kg, both above RBC and background levels. Arsenic was found in soil surface and sediment samples above RBC and SSL. On-site background levels for arsenic range between 3.5 mg/Kg to 23 mg/Kg (Ref. #26). The surface sample was 31.2 mg/Kg and the sediment sample 41.5 mg/Kg, both above RBC and background levels. Thus, it appears that these elevated concentrations of metals may be related to past activities at Ash Pit #1.

The monitoring wells we recommended to be installed just south of Pentolite Road and upgradient of the PBRF would detect contamination migrating toward the PBRF and potentially impacting that facility.

4.8.5 Acid Area #3

Acid Area #3 (AA3) is located upgradient of the PBRF in the western-most portion of the adjacent area of the PBRF (see Figure 4.8-1). The area is a rectangular shape and it covers approximately 10 acres (Ref. #21). It is approximately 2,100 feet from the PBRF boundary. AA3 is located along Ransom Road with approximately three-quarters of the AA3 area north of Maintenance Road and one-quarter of the AA3 area south of Maintenance Road (see Figure 4.8.5-1). Abandoned single-track rail spurs cross the area in a north/south direction. The foundations of buildings and other structures also currently exist on the site (Figure 4.8.5-2) (Ref. #21). Building #9215 (Warehouse D-9) is currently located on the AA3 site and is used for storage by NASA (Ref. #21).

4.8.5.1 *History*

PBOW Operational Period: 1941-1945

AA3 was constructed in 1941 as part of the PBOW for the production of oleum (sulfuric acid) and nitric acid that were used in the production of TNT and pentolite (Ref. #21). A number of buildings existed on the site during this period. AA3 was shut down when the entire PBOW was shut down in mid-December 1945.

Post PBOW Operational Period: 1945 to Present

Decommissioning and decontamination of the acid, pentolite and DNT processing lines began after the plant was shut down in late 1945. Decontamination was completed in the 1960s in accordance with Department of Defense (DoD) standards at that time (Ref. #33). Buildings and structures were removed from AA3 but the date of their removal is unknown (Ref. #21).

4.8.5.2 *Physical Characteristics of Acid Area #3*

The terrain of AA3 is relatively flat with an average elevation of approximately 635 feet above MSL. AA3 is located on grassland and the site area is covered with trees and bushes (Ref. #33). Surface runoff in AA3 flows west toward a tributary of Pipe Creek (Ref. #21). Exact direction of groundwater flow has not been established at AA3. In general, groundwater flow at the PBS is in a northerly direction, towards Lake Erie, in both the overburden and bedrock aquifers. On the western side of the PBS, however, groundwater in the overburden flows to the northwest, while groundwater in the bedrock flows to the northeast toward the PBRF (Ref. #33).

4.8.5.3 *Previous Environmental Investigations*

In 1998, a Site Investigation was conducted at AA3 (Ref. #33). The Site Investigation also examined two other areas associated with AA3: the former Maintenance Shop Area (MNT), located in the west central portion of the AA3, and the former Power Substation (PSS), located across Ransom Road, just north of Maintenance Road (see Figure 4.8.5-2). Overburden and bedrock groundwater samples at AA3 were collected in the Site-wide Groundwater Investigation (Ref. #33).

Sample Results

Surface Soil

A total of 20 surface soil samples were taken at AA3 including 2 surface samples at the PSS and 3 surface samples at the MNT area. The depth of the surface samples was 0-1 foot. The surface soil samples were tested for VOCs, SVOCs, explosive compounds, PCBs and metals (Ref. #33). Table 4.8.5.3-1 below summaries the results above RBC and SSLs for AA3 surface soil samples.

TABLE 4.8.5.3-1 — *Results Of Surface Soil Samples at Acid Area #3*

	RBC (1/10th) [µg/Kg]	# of samples above RBC	Low	High	SSLs (DAF 1) [µg/Kg]	# of samples above SSLs
SVOCs						
2,4-Dinitrotoluene	16,000	None	NA	NA	29	1
2,6-Dinitrotoluene	7,800	None	NA	NA	12	1
2-Methylnaphthalene	160,000	None	NA	NA	110	1
Benzo(a)anthracene	870	2	2100	3500	73	7
Benzo(a)pyrene	87	7	2200	3300	19	9
Benzo(b)fluoranthene	870	2	2400	3400	230	6
Carbazole	32,000	None	NA	NA	23	2
Dibenz(a,h)anthracene	87	None	NA	NA	7	1
Indeno(1,2,3-cd)pyrene	870	2	1200	1400	640	2
Naphthalene	160,000	None	NA	NA	7.7	1
PCBs						
Aroclor 1260	320	4	330	3200	NA	NA
Metals						
	RBC (1/10th) [mg/Kg]				**SSLs (DAF 1) [mg/Kg]**	
Aluminum	7800	6	7940	11800	NA	NA
Arsenic	0.43	20 (all)	2.5	9.6	0.0013	20 (all)
Barium	550	None	NA	NA	110	1
Chromium	23	None	NA	NA	2.1	20 (all)
Iron	2300	20 (all)	6810	26600	NA	NA
Manganese	160	18	182	922	48	20 (all)

NA = Not Applicable

Three VOCs were detected in surface soil samples, but concentrations were well below their respective EPA Region III RBCs for residential soil and SSLs.

As the table above details, only four SVOCs - Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, and Indeno (1,2,3-cd) pyrene - were detected above RBCs. Six other contaminants were detected above SSLs. The majority of the samples above RBCs were found in the AA3 area. Only one sample from the PSS with exceeded RBC, while no samples were detected above RBCs in the MNT (Ref. #33).

A polychlorinated biphenyl (aroclor 120) was detected in five of the 15 samples from AA3, in both of the samples from the PSS, and in one of the three samples in the MNT (Ref. #29). Of these, three AA3 samples exceeded RBC, two PSS samples exceeded RBC, but no MNT samples exceeded RBC (Ref. #33).

A total of 14 metals were detected in surface soil samples within the AA3 and associated PSS and MNT areas. Aluminum, arsenic iron and manganese were detected above RBCs and SSLs (Ref. #33). One sample contained barium and all samples contained chromium at levels above SSLs.

Subsurface Soil

A total 18 subsurface soil samples were taken at AA3 including 3 subsurface samples at the MNT area. The subsurface samples were taken in 2 foot intervals and ranged from 2-4 ft, 6-8 ft and 8-10 ft. The subsurface soil samples were tested for VOCs, SVOCs, explosive compounds, and metals (Ref. #33). Table 4.8.5.3-2 below summaries the results for all those contaminants above RBCs and SSLs.

TABLE 4.8.5.3-2 — *Results of Subsurface Soil Samples at Acid Area #3*

	RBC ($1/10^{th}$) [µg/Kg]	# of samples above RBC	Low	High	SSLs (DAF 1) [µg/Kg]	# of samples above SSLs
VOCs						
Methylene Chloride	85,000	None	NA	NA	0.95	1
SVOCs						
2,4-Dinitrotoluene	16,000	None	NA	NA	29	1
2,6-Dinitrotoluene	7,800	None	NA	NA	12	1
Benzo(a)anthracene	870	None	NA	NA	73	1
Benzo(a)pyrene	87	1	NA	340	19	1
Benzo(b)fluoranthene	870	None	NA	NA	230	1
Naphthalene	160,000	None	NA	NA	7.7	1
Metals						
Aluminum	7800	10	8350	11900	NA	NA
Antimony	3.1	2	7.4	8	0.66	2
Arsenic	0.43	18 (all)	2.5	32.2	0.0013	18 (all)
Barium	550	None	NA	NA	110	1
Chromium	23	None	NA	NA	2.1	18 (all)
Iron	2300	18 (all)	5720	34300	NA	NA
Manganese	160	17	173	1180	48	20 (all)

A total of six VOCs were detected in subsurface soils within AA3. Three VOCs were detected in the MNT area. All detected VOC concentrations, however, were below their respective RBCs for residential soil (Ref. #33). Methylene chloride was detected above SSL in a single sample in the AA3 area.

Twenty SVOCs were detected in the subsurface soil samples. Of these, only 1, benzo(a)pyrene, was detected above RBCs (Ref. #33). A total of six VOCs were detected above SSLs.

Fifteen metals were detected in the subsurface soil samples collected within the AA3 and associated MNT and PSS areas. Five metals – aluminum, antimony, arsenic chromium, iron and manganese – were detected above RBC. Barium and chromium were detected above SSLs (Ref. #33).

Groundwater

For the Site-Wide Groundwater Monitoring Report (Ref. #35), one well was installed in 1997 and another adjacent to it in 1998, and samples were taken for both overburden and bedrock groundwater. The wells are located north of Maintenance Road and east of Ransom Road across from the northern top third of AA3.

The samples in the overburden were tested for VOCs, SVOCs, nitroaromatic explosives, metals (total and dissolved), and cyanide. No VOCs, SVOCs, nitroaromatic explosives or cyanide were detected. Six unfiltered samples and one filtered sample were above $1/10^{th}$ RBC for tap water. Results are detailed below in Table 4.8.5.3-3 (Ref. #33).

TABLE 4.8.5.3-3 — *Results of 1997 and 1998 Overburden Groundwater Samples from Acid Area #3*

	RBC ($1/10^{th}$) [μg/L]	1997 Sample	1998 Sample
Metals			
Aluminum (unfiltered)	3700	11600	ND
Arsenic (unfiltered)	0.045	10.3	ND
Chromium (unfiltered)	11	22.8	ND
Iron (unfiltered)	1100	27300	ND
Lead (unfiltered)	15	16.6	ND
Manganese (unfiltered)	73	816	123
Manganese (filtered)	73	78.8	139

ND = Non Detect

Groundwater samples in the bedrock were tested for VOCs, SVOCs, nitroaromatic explosives, metals (total and dissolved), and cyanide. Two VOCs and two SVOCs were detected in the 1997 sample but only bis(2-ethlhexyl)phthalate was above its RBC of 4.8 μg/L at a concentration of 5.8 μg/L. The 1998 sample showed no concentrations of VOCs or SVOCs. Nitroaromatic explosives and cyanide were not detected in the sample for either year. Aluminum, iron, manganese and zinc were detected in the unfiltered and filtered samples, but only manganese was detected above its RBC of 73 μg/L at 74.6 μg/L in 1997, and 83.8 μg/L in 1998 (Ref. #35).

4.8.5.4 *Conclusions*

The Site Investigation of AA3 concludes that while surface soil sampling reveals a limited amount of SVOCs and PCBs in the AA3 and PSS areas (not the MNT area), the SVOCs were less prevalent in the subsurface soil samples, probably due to reduced mobility of the detected compounds (Ref. #33).

The Site-wide Groundwater Monitoring Report concludes that results from the overburden and bedrock groundwater samples in the AA3 area indicate the groundwater has not been impacted by past site activities. Although elevated levels of manganese were found in both the overburden and bedrock groundwater samples, the report states that these concentrations are low compared to other areas of the PBOW and that manganese is not believed to be a site-related contaminant (Ref. #35). Neither does the report attribute the sporadic detection of low levels of VOCs and SVOCs to be site-related contaminants (Ref. #31).

It is unlikely that the low levels of contamination in this area will affect the PBRF. If monitoring wells are installed just south of Pentolite Road as previously recommended, samples from those wells would indicate if any contamination is migrating towards the PBRF.

4.8.6 Overall Conclusions for the PBOW Sites

Of all the adjacent areas to the PBRF reviewed above, the PRRWPs remain the closest and most contaminated area of concern. The other PBOW sites discussed could also potentially contribute to contamination migrating towards the PBRF. With the installation of nested overburden and bedrock monitoring wells just south of Pentolite Road and upgradient from the PBRF, it will be possible to determine if contaminants are migrating from all of the areas of concern in the adjacent area to the PBRF. Figure 4.8.6-1 shows the approximate recommended locations of these wells. During the review of available data, nothing was found that would indicate that any NASA activities at the PBS have caused contamination in the adjacent areas that could migrate to the PBRF; all such contamination appears to be related to the former PBOW activities.

4.8.7 Summary of the Vista Check Database Search

A search of Federal and state environmental databases for known sites within 1.5 miles of the PBRF was conducted through the Vista Check Database System. The ASTM Site Assessment Plus Report is included as Appendix F of this EBSR. In addition to the database searches, the report includes Sanborn Fire Insurance Maps, and a U.S. Department of the Interior land use and land cover map (from source materials dated 1980 and 1983). However, no historic fire insurance maps (Sanborn maps) are available for the PBS area. This indicates that the area was undeveloped in the late 19th and early 20th centuries. As discussed in Section 3.1, historically, the area was used for agriculture until the DoD obtained the property in 1940.

As shown in Appendix F, several sites of interest were identified in the Federal and state database searches (see the figure on page 3 of Appendix F). These are located between ¾ and 1 mile from the PBRF and all but one are located on the PBS. A state-registered inactive leaking UST (LUST) is located 0.82 miles northeast of the PBRF at the Perkins Board of Education on E. Bogart Road. This site is listed as “No Further Action” in the database and is downgradient of the PBRF.

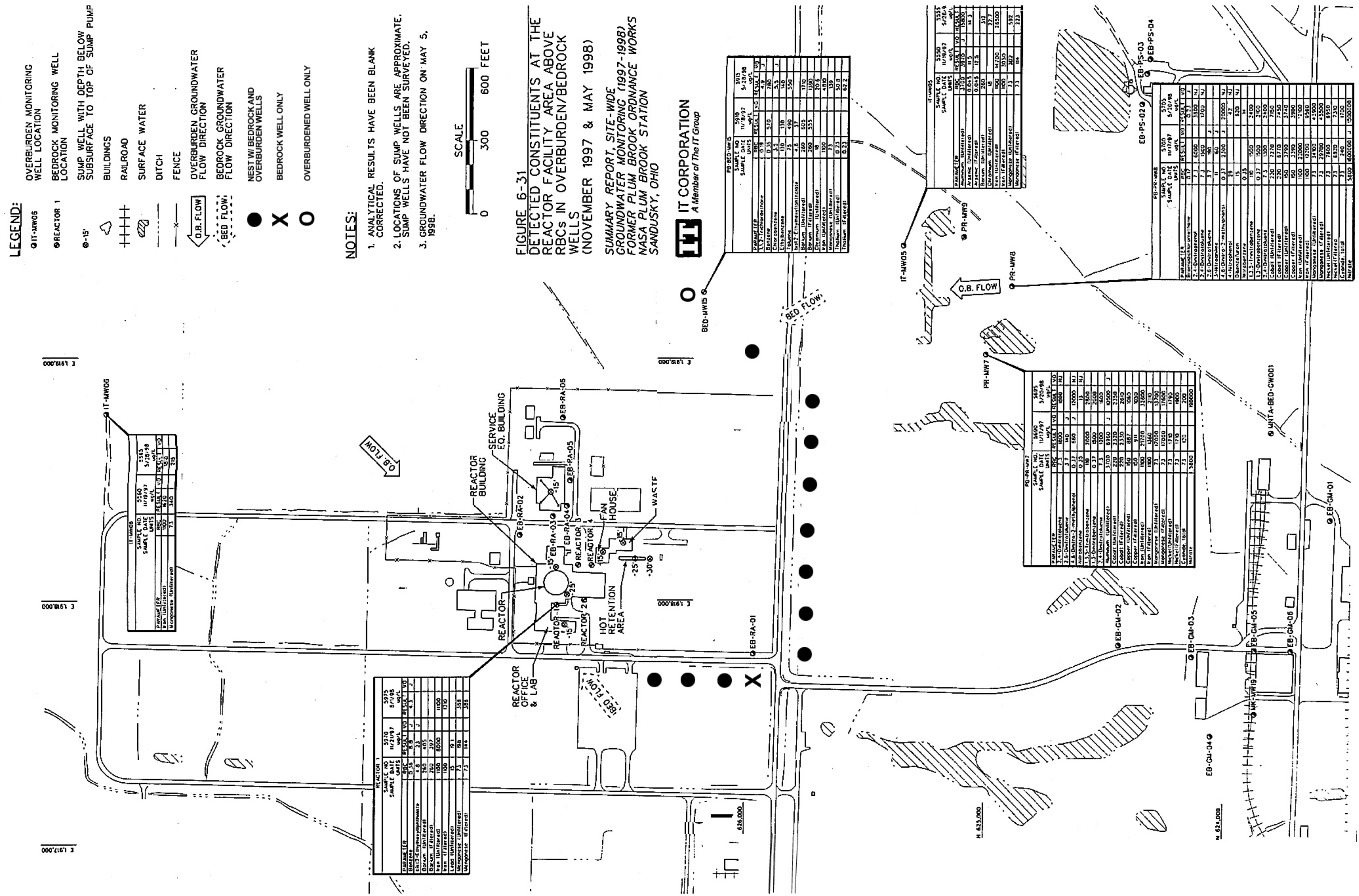

FIGURE 4.8.6-1.—Recommended Locations of Overburden and Bedrock Monitoring Wells Upgradient of the PBRF.

(Source: Ref#35 modified)

All other sites identified are within the boundary of the PBS. Four sites are identified with building numbers. The LUSTs at Buildings #8951, #5231, and #7132 are listed as inactive and require no further action. The LUST at Building #7121 is listed as active and also requires no further action.

The database also identified PBS as a large quantity generator under RCRA, as a site undergoing RCRA corrective actions, and also as a site that has undergone Federal discovery, preliminary assessment, and screening site inspection activities.

The report also identifies seven unmapped sites, 5 of which are LUSTs and 2 are solid waste landfill facilities. All areas upgradient of the PBRF that could affect that facility are located on the PBS. These unmapped sites are not located on the PBS. Therefore, it is expected that these 7 sites could not adversely affect the PBRF.

Similarly, the overall results of the ASTM Site Assessment Plus Report do not indicate any additional sources of contamination that could affect the PBRF. As discussed above in Section 4.8.6, the former PBOW sites located upgradient of the PBRF are the areas of concern within the adjacent areas.

4.8.8 Private Groundwater Wells

The 1991 Preliminary Assessment detailed water utilization for the PBS and all other users within 15 miles of the Station (Ref. #12). Within a 4-mile radius of the PBS, there are 179 permitted private drinking water wells on record at the Erie County Health Department. The Erie County Health Department does not require a permit for wells intended for agricultural use. Figure 4.8.8-1 shows the permitted drinking water wells and those areas served by rural, city or county water authorities. As the figure shows, permitted private wells are located side-gradient to the entire PBS. The area downgradient from the PBS are serviced by the various local water authorities which obtain their water from surface water supplies including Lake Erie and reservoirs fed by the Huron River (Ref. #12).

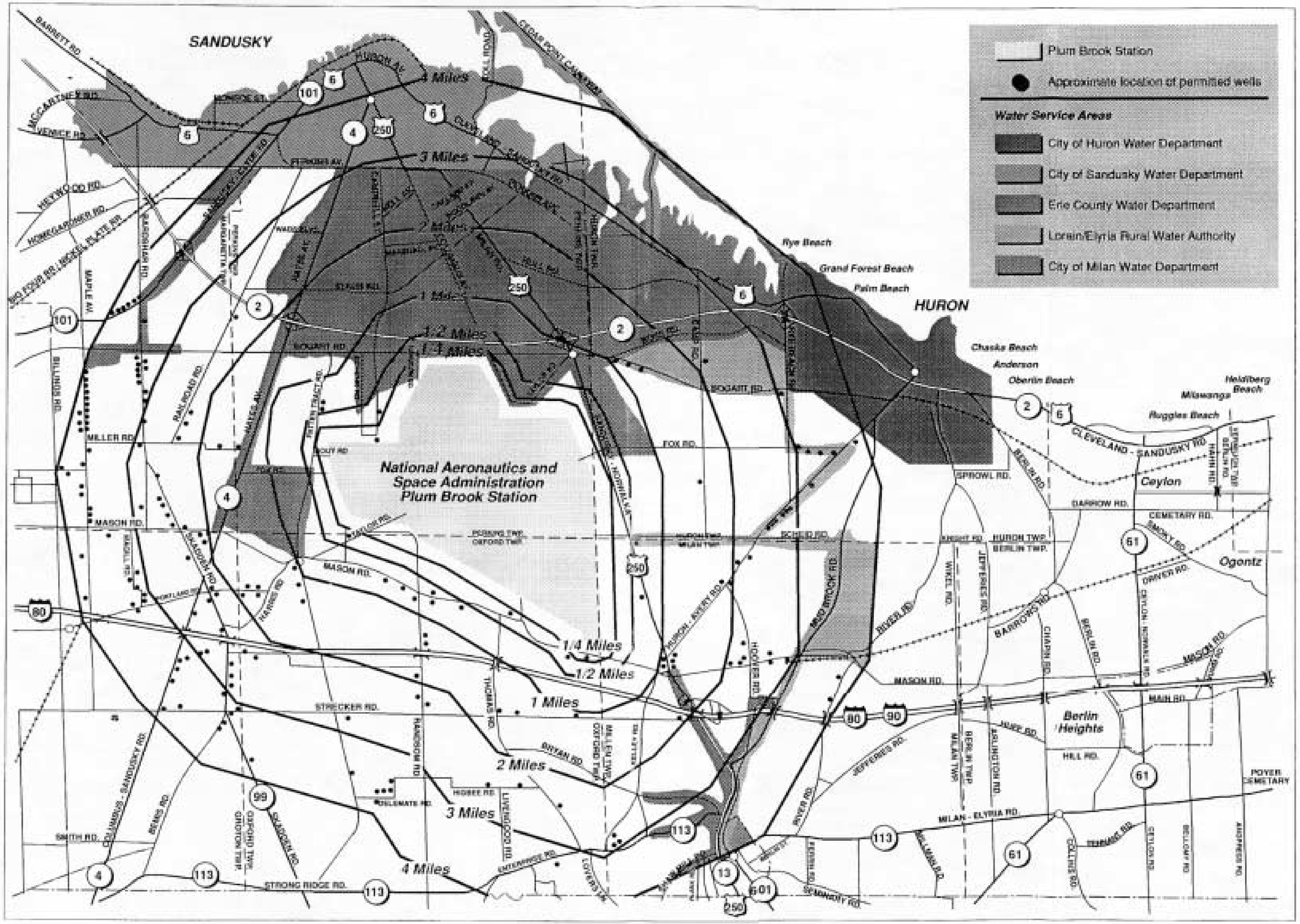

FIGURE 4.8.8-1.—*Permitted Drinking Water Well Locations Within a Four-Mile Radius of PBS, and Water Service Areas.*

(Source: Ref#12)

5.0 CONCLUSIONS AND RECOMMENDED COURSES OF ACTION

This section presents conclusions and also discusses current data gaps and future recommended investigations.

5.1 CONCLUSIONS

Upon analyzing data collected during the conduct of this EBS, the following conclusions can be made:

Due to the nature of the facility, environmental monitoring conducted while the facility was active focused solely on radiological aspects. The radiological characterization efforts conducted in 1985 and in 1998 appear to have adequately characterized the radiological status of the buildings and structures at the PBRF. However, during this EBS, no information was obtained on the extent of the contamination associated with the former spill area south of the Waste Handling Building (#1133).

Since the facility has been shut down, sampling for environmental contaminants other than radionuclides has occurred. This has been associated with the USTs adjacent to the Services Equipment Building (#1131), the former Pentolite Area Waste Lagoons that were present in what is now the southwestern part of the PBRF, and recent environmental characterization efforts associated with the decommissioning project.

Sampling and analyses conducted at the former UST area appears to have adequately characterized the nature and extent of the contamination associated with these tanks. Future remedial actions involving the groundwater contamination in this area should reduce contaminant levels.

Although soil sampling conducted to date in the former Pentolite Area Waste Lagoons is somewhat limited, the available data indicate that there is no nitroaromatic soil contamination remaining in the area. In fact, the state EPA representative overseeing the DERP/FUDS work at the PBRF has indicated that the request for “no further action” at the former Pentolite Area Waste Lagoons will be approved (personal communication w/ Ms. Lisa Humphreys, December 2000).

The most recent soil sampling effort at the PBRF (Ref. #50) identified several areas of low-level VOC, SVOC, and PCB soil contamination. However, except for 1 sample that contained an estimated concentration of an SVOC above the RBC, the concentrations detected were well below available RBCs.

The environmental condition of the PBRF appears to be adequately characterized, with the exception of the data gaps discussed below in Section 5.2.

5.2 DATA GAPS AND RECOMMENDED INVESTIGATIONS

Various data gaps have been identified during conduct of this EBS. Several of these gaps concern lack of data on certain types of potential contaminants (based on site activities and history), others are lack of sampling in certain areas, and one was identified during the review of historic aerial photographs. The specific data gaps identified are discussed below.

During interviews with personnel who worked at the PBRF when it was active, it was noted that the analytical laboratories at the PBRF used typical solvents associated with laboratories, such as carbon tetrachloride, acetone, and methylene chloride. Waste solvents were disposed of by pouring them down the drains at the laboratories. Because the laboratories handled radioactive materials, these drains are part of the hot drain system that discharged to the tanks in the Hot Retention Area (#1155). Liquids stored in this area were allowed to "cool" and were then diluted with non-radioactive water and discharged through the Water Effluent Monitoring Station (WEMS) (#1192). Although the solvents disposed of were certainly diluted greatly in this process, in addition to the dilution that occurred in the Hot Retention Area, it is possible that the sediments at the WEMS may have been contaminated by volatile organic compounds. Sediment and subsurface (to a depth of 5-feet) sampling/volatile organic analyses should be conducted at the WEMS to verify that no VOC contamination exists. Three sediment samples collected from random locations should be sufficient to determine if this area has been impacted by solvent contamination.

There is another potential source of VOC contamination being introduced into the WEMS. This source is the current discharge of water from the sumps in the basements of the major buildings at the PBRF. Due to the depths of the wells at the sumps, it is safe to assume that this water is from the bedrock aquifer. The RCRA investigation conducted at the former waste solvent tank site found that the sump at Building 1131 has caused a radial depression of the groundwater table towards the sump. Although the former waste solvent tank site could be contributing to the VOC contamination, the sump effluent is monitored quarterly for radioactive constituents only; VOCs are not an analyte.

During the sitewide groundwater monitoring study (Ref. #35), benzene was detected in Reactor Well #1 (a bedrock well) at a concentration of up to 8.8 ug/l (the RBC is 0.36 ug/l). Although benzene is known to be naturally occurring in the area and has been found in most bedrock monitoring wells across Plum Brook Station, it is not know to naturally occur in surface water. The sump effluent is discharged through the WEMS, into Pentolite Ditch and then into Plum Brook. Since the sump effluent is from the bedrock aquifer, there is potential for it to be contaminated with VOCs, particularly benzene. A grab sample of the sump effluent at the WEMS should be collected when it is not raining (to avoid dilution by storm water) and analyzed for VOCs.

Although not specifically identified during either the records search or interviews, there is another potential source of contamination associated with the laboratory drainage system. Because of the nature of the laboratory operations, potential exists for substances such as mercury from broken thermometers to have been disposed of in sink or floor drains. Therefore, during demolition of the laboratory areas, sludge present in the laboratory floor drains and sink traps, and any material present between floor sub-surfaces should be sampled and analyzed for a complete set of analytical parameters (i.e, VOCs, SVOCs, Target Analyte List metals, and pestcides/PCBs).

The Sludge Basins (#1153) in the northeast corner of the PBRF and the associated Drying Basins in the northern area outside the PBRF fence have never been sampled. This is because these basins were part of the raw water treatment system and thus are not suspected to have radiological contamination. However, the potential use of algaecides or similar substances to control microorganism growth in the process water leads to the possibility that the sludge/sediment in the Sludge Basins and what is now soil in the Drying Basins may be contaminated with these substances. Several sediment and soil samples should be collected in each of these areas at random locations and analyzed for pesticides/herbicides and metals. If any contaminants are detected, a sampling grid system should be established over each basin and an appropriate number of random samples should be collected in accordance with EPA guidance.

As discussed in Section 4.2.13, the diesel fuel above ground storage tank just north of the Services Equipment Building (#1131) was overfilled in about 1975. Soil sampling of the impacted area was never conducted. In addition, stained soil was observed below the tank during the site visit. This area and the soils between the tank and the catch basin located approximately 60 feet north of the tank should be sampled and analyzed for diesel range organics and total petroleum hydrocarbons. Composite samples should be collected from a depth of 0 – 2 feet from beneath the tank and then at 10-foot intervals to the catch basin.

Based on the data reviewed for this EBS, it appears that the overburden groundwater in the central portion of the PBRF has not been analyzed for nitroaromatics. Reactor Well 2, a bedrock well, was sampled in 1995 during the Focused RI at the Pentolite Road Red Water Ponds, and 3-NT and 3,4-DNT were found at levels of 23 ug/l and 13 ug/l, respectively. The Limited Site Investigation of the former Pentolite Area Waste Lagoons (Ref. #36, 1999) did not identify nitroaromatic contamination in soils, and concluded that the potential for groundwater contamination was therefore low. Groundwater, however, was not sampled as part of this investigation. Overburden groundwater at the PBRF should be analyzed for nitroaromatics in order to verify that the former Pentolite Area Waste Lagoons did not impact groundwater at the facility.

During the review of data conducted for this EBS, no information was found on the extent of the area of contamination from the 2 areas of low-level waste spills (just south of Building #1134 and south of Building #1133). Soils were sampled to a depth of 10 feet in the area south of the Waste Handling Building (#1133) in the 1985 characterization study, and contamination was reported to a depth of 6 feet. No direct indication of the areal extent of the contamination was given (It was stated that soil should be removed to a depth of 8 feet and that a total of 185 cubic yards of soil should be removed. Assuming a square excavation, this would imply an area of 25 feet on each side). No radiological concentration was reported in the 1985 study for the second spill area near the Primary Pump House (#1134). The 1998 survey confirmed the presence of contamination near the Waste Handling Building, but no contamination was detected at the previously identified spill area. The lateral extent of the spill near Building #1133 should be determined, and the presence or absence of contamination associated with the second spill should be verified.

During the review of historic aerial photographs taken during construction of the PBRF, piles of unknown material were observed in what is now the parking lot (see photo in Appendix B). This material appears to be fill, but its origin is unknown. It is possible that this material was obtained onsite. Given the history of the Plum Brook Ordnance Works, the area beneath and immediately south of the parking lot may have been filled with soil contaminated by nitroaromatics. Although this area is outside the fenced portion of the PBRF, it is recommended that ten soil samples (composites from 0 – 2 feet) be collected in these areas and analyzed for nitroaromatics.

Finally, as discussed in Section 4.8.6, since the PBRF is downgradient of several former PBOW sites located in the adjacent areas south of the PBRF, there is potential for groundwater contamination from these sites to migrate towards the PBRF. With the installation of monitoring wells just south of Pentolite Road and upgradient from the PBRF, it will be possible to determine if contaminants are migrating from all of the areas of concern in the adjacent area to the PBRF. The approximate recommended locations of these wells were presented in Figure 4.8.6-1.

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CERTIFICATION OF
FINAL ENVIRONMENTAL BASELINE SURVEY
FEBRUARY 2001
FOR PLUM BROOK REACTOR FACILITY,
SANDUSKY, OHIO

I certify that the property conditions stated in this report are based on a thorough review of available records, visual inspections, and sampling and analysis as noted, and are true and correct, to the best of my knowledge and belief.

____ ____________________

Preparer/Affiliation Date

I have reviewed the preparer's methodology and report, and concur with the methodology and findings to the best of my knowledge and belief.

____ ____________________

Chief, NASA GRC Environmental Management Office Date